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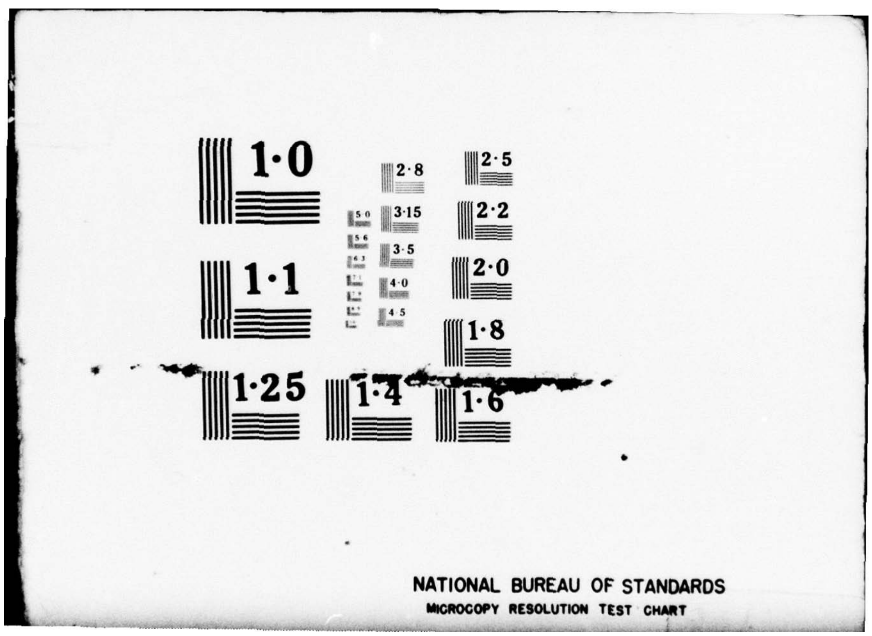
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proceedings of the first FAA general aviation research & development conference

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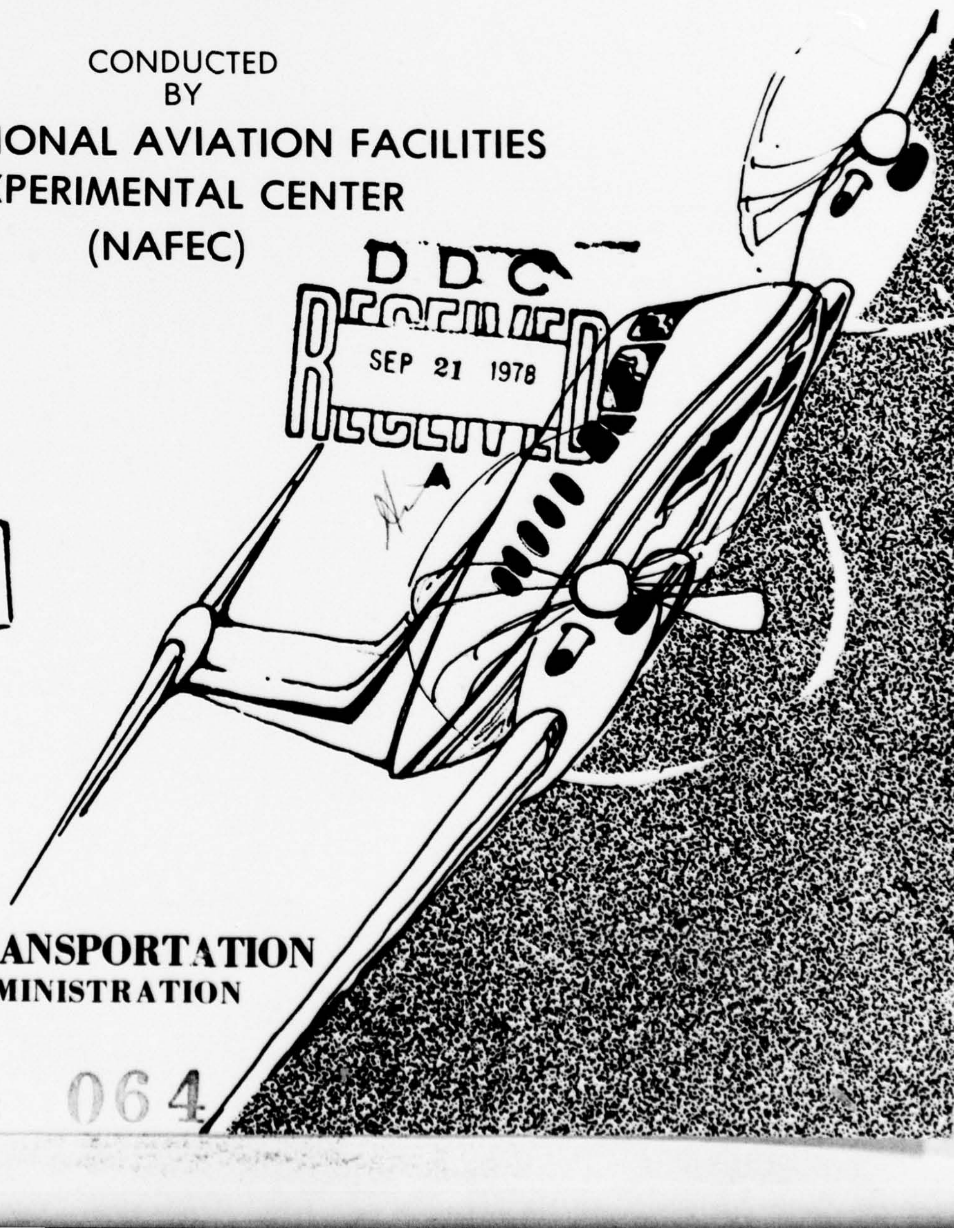

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Atlantic City, NJ

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16. Abstract

More than 250 representatives of the aviation community attended the Federal Aviation Administration's (FAA) first General Aviation Research and Development (R&D) Conference on August 17 and 18, 1977 which was organized and hosted by the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey.

The purpose of the conference was to discuss current and future FAA, R&D programs with the intent of formulating plans for conducting additional research programs in the areas most needed by General Aviation. It also was aimed at building a better working relationship with general aviation users in areas of material interest. → next page

FAA Administrator Langhorne M. Bond addressed the opening session followed by by FAA and NASA technical briefers who covered a variety of general aviation R&D programs. The consensus of those who attended, indicated that the conference was beneficial, informative, and interesting.

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PREFACE

More than 250 representatives of the aviation community attended the FAA's first General Aviation Research and Development Conference on August 17-18, 1977, organized and hosted by NAFEC at their Atlantic City, New Jersey facilities. The conference was followed by one-half day of tours of NAFEC test sites and facilities.

The purpose of the conference was to discuss current and future FAA, R&D programs with the intent of formulating plans for conducting additional research programs in the areas most needed by General Aviation. It also was aimed at building a better working relationship with general aviation users in areas of mutual interest. The consensus of those who attended, indicated that the conference was beneficial, informative and interesting.

FAA Administrator Langhorne M. Bond addressed the opening session followed by FAA and NASA technical briefers who covered general aviation R&D programs under the session categories of Airmen and Airports; Aircraft; Aviation Weather and FSS; Flight Service Station; and Air Traffic Control.

cont.

Under Airmen, the agenda included a review of pilot training techniques, pilot judgment, and pilot medical studies in such areas as night vision, the aging process and human tolerance to impact forces. Airport projects covered included low-cost marking and lighting for small airports, low-cost fire rescue equipment and frangible light structures. Aircraft subjects discussed included improved survivability for general aviation aircraft, NASA's stall/spin program for light aircraft, and engine emissions requirements and testing. The conference also focused on aviation weather problems and what is being done to reduce their impact on general aviation operations with attention also given to FAA's flight service station modernization program. Air traffic control subjects presented included area navigation, small community microwave landing system and the role of General Aviation in the evolving Air Traffic Control System.

These topics were complemented by corresponding presentations from the general aviation community by: Professor Jack J. Eggspuehler, Ohio State University; James T. Pyle, NPA; Austin B. Brough, AAAE; Stanley J. Green, GAMA; John H. Winant and William Horn, NBAA; and John L. Baker and Victor J. Kayne, AOPA.

Each conference session was summarized by the session chairman with added emphasis and direction provided by the FAA's Deputy Administrator, Quentin S. Taylor in his closing remarks.

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Administrator of the
Federal Aviation Administration

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Deputy Administrator of the
Federal Aviation Administration

Mr. Albert P. Albrecht
Deputy Associate Administrator
for Engineering and Development
of the Federal Aviation Administration

Mr Robert L. Faith
Director of the
National Aviation Facilities
Experimental Center of the
Federal Aviation Administration

HOST

CONFERENCE WELCOME AND OVERVIEW

MR. ROBERT FAITH

I am Bob Faith, the Director of the National Aviation Facilities Experimental Center, and I would like to take this opportunity to welcome each and every one of you to the first General Aviation Research and Development Conference. It is my hope and wish, together with all the members of the FAA, and I know, you people from industry, that this will be a most informative, as well as a productive, meeting. It is now my great pleasure to introduce to you the Administrator of the FAA, Mr. Langhorne Bond.

MR. LANGHORNE BOND

Ladies and gentlemen, Regional Directors visiting from the Mid-West, and others who are here, I want to promise you that this may be the first, but I give you my word that this is not going to be the last conference on the subject of R&D in General Aviation. I think it's pretty obvious that, numerically, at least in terms of the use of the air traffic control system, and certainly from the point of view of the preoccupation of the Administrator, one I can testify directly, General Aviation constitutes the bulk of our work and our preoccupation.

Where I come from, people I dealt with all of my life accept the use of General Aviation as the natural part of the business, economic, and even the recreational life of the United States. The vital role that General Aviation plays in our country cannot be overestimated. It is just part and parcel of our economic growth.

It's cheap; General Aviation is, and I say that quite deliberately because, like many important investments, the front-end costs are a little high. However, when you consider the time that is saved and the alternative costs, any investment that a business can make in General Aviation or that the government can make in General Aviation is money well spent. I am committed to it. The FAA is committed to the support of General Aviation. I think our record in the past few years will bear that out.

I promise you that I will leave no stone unturned, no fellow bureaucrat unharrassed in the pursuit of the interests of General Aviation. The days of apologizing for our role in life as General Aviation enthusiasts are over, period. General Aviation is what makes the economy of our country go around. The hard dollar export cash flow that is caused by General Aviation is also significant. And once again American technology, American government leadership, and American business leadership have made our great country the premiere force in non-air carrier aviation. I promise you that we in the FAA will do our very best to continue to let the private sector generate its own ideas and its own techniques in General Aviation.

Our role in this business, as I perceive it, is not to supplant what businesses in the private sector can do best for themselves. Our work here in the research and development program I view as supplementary to what you do. I recognize that the ability of the private sector to do things cheaply, quickly, and economically is inherently superior to whatever the government can do. In the pursuit of the promotion of General Aviation, I will try to dismantle as many government barriers that get in the way as possible, rather than try to take over the privacy and leadership.

We would like to be a partner, but a subordinate partner, to those in the private sector. General Aviation is going to be high on our list. It is equal to other uses of the airspace. All segments of our business are equal. Each has an equal title to the use of airspace, an equal claim on our time, and an equal role in the development of the economy of the United States. It is, therefore, to assure that equality that I will work over the next 4 years.

I hope that when the 4 years are up, those of you who are in the General Aviation business will think charitable of me, but I am prepared to stand on my record. If it goes wrong, I am prepared to say it was my fault. I believe in accountability in government. One man or one woman can make a difference, and I intend to exert the thought and leadership in General Aviation that you should expect from the FAA Administrator. Thank you very much.

MR. A. P. ALBRECHT

Good morning ladies and gentlemen, it is a pleasure to be here. Jeff Cochran looked forward to this conference, and was heavily involved in getting the wheels rolling to make it possible. Unfortunately, he is home with the flu today, so I will have the honor of passing on his remarks to you. The Administrator, in his remarks, set forth the FAA's continued and expanded recognition of the role General Aviation has in our overall national and international aviation community. Normally, when I speak, I am outlining our programs and digging into troublesome specifics, but today and tomorrow we have real experts here to do that material up for you in style. So I am going to generalize, for a little bit, share our thoughts, solicit yours, and stress the need for us to mutually support each other. Our forecasters tell us that traffic is going to double by 1985 and quadruple by the year 2000. They also tell us that General Aviation is going to be the largest portion of that increase. I am just like everybody else when it comes to forecasts, but they have been hitting numbers pretty consistently and if we recognize there are some assumptions in making the forecasts, mostly fuel related, they tell us that we best get ready to meet this demand. What this means to us is that you are our biggest challenge in the next decade. How can we serve you and not help you too much? Your independent and occasional hard-nosed opinions are recognized and, believe it or not, most of the time appreciated. There is and must be an air traffic control system, and the system must be so structured as to allow those who operate within it to do so in an economical and efficient manner and yet be consistent with

their needs and the overall safety of everyone within the system. In the United States, we recognize the freedom of flight concept. To us, this means that you should be able to operate within or without the system. The choice is yours. Within, you will have to come equipped with certain black boxes. Without, it's your choice beyond the basic regulatory requirements. Our challenge is to facilitate the provision of those black boxes in a cost range and in an uncomplicated configuration that will assist you in exercising your freedom of flight. They must be inexpensive, simple, and responsive to your needs. Our planning and programs recognize these requirements and they will, in the next several years, emphasize these requirements. But it can't all be government. Industry must also put some of their knowledge and R&D resources to work. Considering the projected growth, the market should be there for industry. Our capability to do any work for any segment of the aviation industry is dependent upon our ability to justify resources to the reviewing authorities in the Congress. Their responsiveness is in no small way a reflection of what the aviation industry tells them about our programs. You realize, as we do, that industry is composed of many varied special interests. Normally, each of the groups find something in our program to support. Unfortunately, they can also find something they don't care for and state it loud and clear. We have briefed, and will continue to brief, all those concerned with our programs and budget requests on what they contain and why. What we are seeking is an understanding by all concerned, strong support for those items nearest and dearest to their hearts, and also the recognition that we have for other constituents who must be served. I hope this gathering and information exchange will help foster that element of our efforts, as well as improve our knowledge of what your requirements are. Thank you for your indulgence and participation.

SESSION I

AIRMEN AND AIRPORTS

Mr. Joseph M. Del Balzo
Deputy Director of the National
Aviation Facilities Experimental Center

CHAIRMAN

Mr. James I. Riddle, Chief
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Section, General Aviation
Operations Branch, FAA
Flight Standards Service

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Mr. James T. Pyle
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Pilots Association,
Former Deputy Administrator of
the FAA

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Airports Branch
Aircraft and Airports Safety Division
National Aviation Facilities
Experimental Center

Mr. Austin B. Brough
Assistant Director of Aviation,
Philadelphia International Airport,
Past President of American Associates
of Airport Executives

AIRMEN AND AIRPORTS SESSION

MR. JOSEPH DEL BALZO

Good morning. I would like to welcome you to the first half of the Airport and Airmen's Session. My job this morning turns out to be an easy one. Al Albrecht talked a minute ago about the experts you are going to listen to today. When I looked at the panel of people who will be presenting their papers today, Al certainly was right. You are going to hear from the experts. And I don't think that I want to waste any time forcing you to sit here and listen to me. I am not one of the experts. I had hoped this morning to be able to tell you that I am one of the general aviation airmen. I dedicated myself to that 2 months ago, when I started taking flying lessons. Yesterday I thought I was ready to solo. I landed the airplane by myself six times without a problem and said, "I've got it, I'm ready to solo." My instructor said, "Why don't we do it just one more time before I get out and put you on your own." I said, "Okay." I had everything set, got it all trimmed up, turning base leg. All was well until my instructor pulled the power back, saying, "Okay you just lost an engine, now what do you do?" I was prepared. You see, he had done that to me a couple of times when we were at altitude and I knew exactly what to do. I made sure that the mixture was rich, checked the carburetor heat, checked the magnetos, checked the fuel pump, and switched fuel tanks--forgetting that the aircraft was descending on its own. Needless to say, I didn't solo that morning. Maybe tomorrow.

EFFECTIVENESS OF GROUND PILOT TRAINERS AND TRAINING FOR PILOT JUDGMENT IMPROVEMENT

MR. JOSEPH DEL BALZO

The first speaker this morning is Jim Riddle. Jim brings with him 20 years of experience as a Navy pilot. He has been with the Flight Standards Service in FAA for the past 8 years, and he is currently Chief of the Certification and Operations Section. He is going to address two subjects in his presentation. The first subject will cover the potential use of simulators and ground training, and certification flight testing. During his presentation he will cover some of the results of studies that have been accomplished to date. The second topic will focus on judgment, training, and evaluation.

MR. JAMES RIDDLE

Good morning ladies and gentlemen. It is a pleasure to be here this morning and represent the General Aviation Division in Flight Standards Service. The FAA is continuously working to standardize and improve training effectiveness in General Aviation. Part of this effort includes the research projects which

Flight Standards generates and directs. In the 1960's there was a growing number of pilot training devices, commonly referred to as simulators, flight trainers, and ground trainers. We have a couple of slides this morning of some of the more sophisticated and even the less sophisticated trainers. This you will see as the Full Motion/Base Visual Simulator used by some of our airlines, figure 1-1. This is a Full Visual Simulator produced by Atkins and Merrill of Tulsa, Oklahoma, a motion base and visual system, figure 1-2.

This trainer, I am sure many of you will recognize, especially if you were in the military in the past few years, figure 1-3. Many of us have many hours in that particular device. And although I believe some segments of the aviation industry would like to believe helicopters are not here to stay, I believe they are. This is a slide of the Coast Guard 62 Simulator, a Full Motion Base Simulator that they used down in Mobile, Alabama, figure 1-4. Figure 1-5 shows a mockup of one of our cockpit procedure trainers. These devices varied in the number and type of aircraft characteristics which they could simulate, and the degree of realism which they could achieve. Their quantitative value had not been established for either private or commercial pilot ratings. As the use of these devices increased, it became necessary to determine what features and characteristics were essential to provide the most effective transfer of training between the learning situation on the ground and the later performance in the air. Research was needed so that the FAA could develop procedures and regulations which would lead to improved general aviation flight operations, increased safety, greater effectiveness, and standardization in pilot training in utilizing these training devices.

In an effort to obtain the information necessary to establish adequate guidelines for authorizing the use of these devices, Flight Standards, in 1970, initiated a request that a study be made of these ground trainers.

The project, which constituted phase 1 of the study, examined the capabilities, necessary characteristics, and effectiveness of pilot ground trainers in developing the primary aeronautical skills, maneuvers, and procedures needed to operate single-engine land aircraft defined in the Federal Aviation Regulations and appropriate flight test guides. The study examined the performance of control and experimental groups demonstrating those primary flight maneuvers. The study was specifically designed to determine:

1. What maneuvers and procedures can be taught effectively in a ground trainer;

2. Which characteristics, instrumentation, and equipment are essential for a trainer to be effective; and

3. What is the best ratio of ground trainer instruction time to flight instruction time that would be acceptable.

The study showed which maneuvers and procedures could be taught effectively and efficiently in ground trainers. It also found that in terms of primary flight instruction, an effective ground trainer reduces normal aircraft instruction by approximately one-third. As an addendum, the study included a review of the flight instructors' ideas on the applicability of ground trainers in a primary curriculum, based upon their experience in the project. In

1973, Flight Standards began directing a research project by NAFEC that continued the previous effort on ground trainers. It was conducted to evaluate a new trainer with a unique means of presenting visual material. This visual system was not available for phase 1 testing, and thus, phase 2 was limited to the determination of the effectiveness of this system for training students in visual flight rule, presolo-type maneuvers. These studies showed that certain maneuvers in specified ground trainers may be taught effectively, thereby reducing the required aircraft instruction time.

As a result of this study, FAA made a decision to take greater advantage of simulators in general aviation flight training and pilot testing. Consequently, certain changes were proposed and later adopted into Parts 61 and 141 of the FAR. One such change provided for the use of a ground trainer in the instruction of ADF and ILS systems. Additionally, certain pilot proficiency checks which were made mandatory for general aviation pilots in revised Part 61, permitted the use of simulators for those checks. The use of simulators here is quite expansive. For example, all of the 12-month proficiency check, and a large portion of the 24-month check, can be conducted in a simulator. Finally, 50 of the 250 hours of pilot time required for a commercial rating may be instruction received in a ground trainer. FAA also established standards for ground trainers to be used in approved pilot certification courses, instrument rating courses, commercial pilot certification courses, and commercial test courses. Flight Standards is continuing to give ground trainers a greater role in general aviation flight training and checking. During the forthcoming operational review of Part 61, we will propose a revision which will provide for the use of a ground trainer during the practical test to verify an applicant's aeronautical skill in demonstrating ILS and ADF approaches.

It has long been the policy of Flight Standards that in the certification process, we should not simply establish requirements but ensure that they are met. What we have tried to do is to ensure that flight training is based on a standard. In order to reach this goal, requirements subject to wide variation, based on subjective evaluation or on so many hours of aeronautical experience, are wholly inadequate. Unfortunately, these are exactly the ways we have been attempting to evaluate pilot judgment. Judgment however, is a much too important part of flying to deal with in this manner. It is an integral part of flying. There is a continual process of assessment, evaluation, and decision that a pilot goes through during the entire course of the flight. As an indication of the importance of pilot judgment, it should be noted that in 80 percent of all general aviation accidents, the pilot has been cited as a causal factor. One of the causes most often noted is judgment; or more exactly, "Pilot displayed poor judgment." Since judgment is such a vital part of the pilot's activity, it is imperative that it be measured, evaluated, and taught; otherwise, our goal of training to a standard will remain unattainable. Our efforts, in this case, have been impeded, particularly at the private and commercial pilot level because of the need to determine the applicant's judgment qualities. The only determination being made now of a pilots judgment is a subjective evaluation made by the person administering the certification practical test. Thus, there is at present, no standard in this area of the certifying process in making a determination of the pilots judgment (if in fact the certifying individual attempts to assess it at all). Often the only attempt at any sort of quantitative evaluation of a pilots judgmental ability is simply an assumption based on the number of years which the designee has been flying. It was

with this in mind that in September 1976, Flight Standards initiated a request that a study be made on judgment, instruction, and evaluation. This study had three specific objectives:

1. Define judgment,

2. Determine whether and how judgment may be taught and evaluated in the context of flight training, and

3. Broadly outline methods for teaching and evaluating pilot judgment.

Each of these steps was constructed so as to build on the previous one, so that at any point, if one of the steps could not be completed then the remainder of the project could be terminated. In this way, Flight Standards continually directs and monitors the progress of the project, and, if necessary, at any point, the project could be terminated saving the costs of the remaining part. To date, the project has continued on schedule and the first two tasks have been completed. In these tasks, theoretical evidence was presented which indicated that certain training methods may be effective in improving cognitive and psychological aspects of human judgment. It was found that these judgmental training methods are applicable within existing pilot training programs such as: (1) ground schools, (2) flight simulator training, and (3) aircraft training. However, the best and most expensive potential judgment training method is: (4) computer-assisted instruction. Under the current training methods, the report emphasized that the flight instructor is the single most important factor in training pilot judgment. The effectiveness of the training depends on the instructor's use of situational teaching techniques and his ability to be a creative and motivated instructor. As a result, the report determined that better training for flight instructors is needed. The report further suggested the use of intelligence and personality tests, and the development of a means of comparing student judgment to a norm. There has not been, as yet, a determination made as to how the adequacy of an applicant's judgment is presently being evaluated. The results of it will form the basis for an answer to this question. We have also agreed that this research should lead to the development and testing of a judgment syllabus in a defined ground trainer, and the development of actual ratios between trainer and flight time for certification requirements. If the current judgment study elicits confidence that this ultimate goal can be achieved, then procurement of funds for such a followup study will be initiated. Both of these research projects have been a part of a continuing goal of Flight Standards. That is--to strive to train to a standard. Flight Standards, in generating and directing these projects, has <u>worked to make flight training more uniform and consistent</u>. In the process we have attempted to make training simpler and more economical by encouraging the use of ground trainers. We have sought to do this first, by increasing our understanding by indepth study and second, by providing for greater use of such devices in the certification process. In this way, we hope to raise the quality of agency certificated pilots in an attempt to attain our ultimate goal--to make our airways as safe as humanly possible. This is the reason behind our research efforts and we believe that continuing research efforts such as these are helping us to reach that goal. Thank you.

FIGURE 1-1

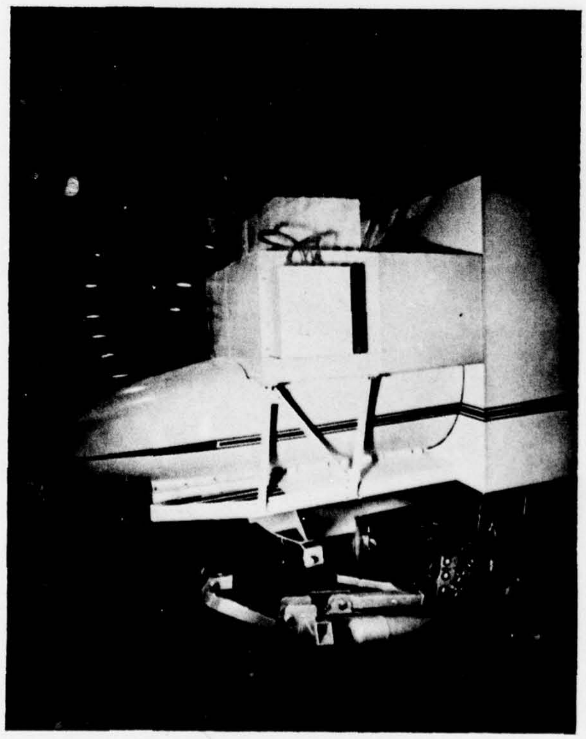


FIGURE 1-2

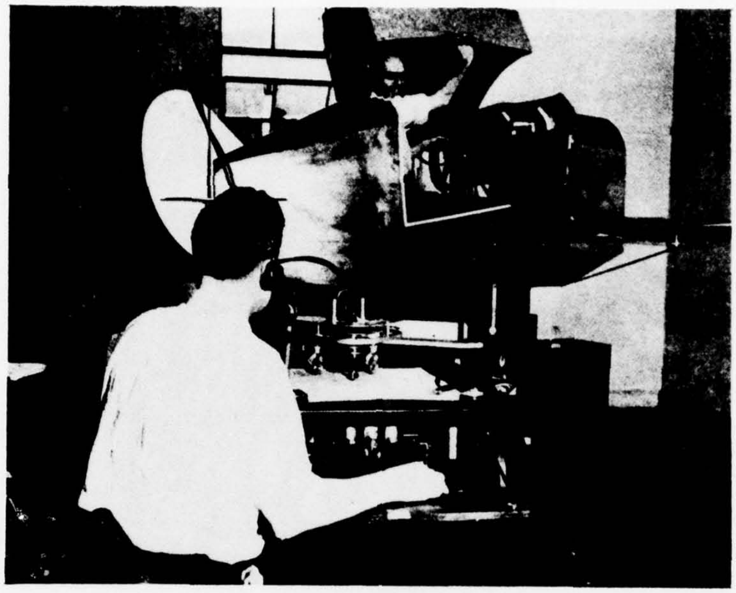


FIGURE 1-3

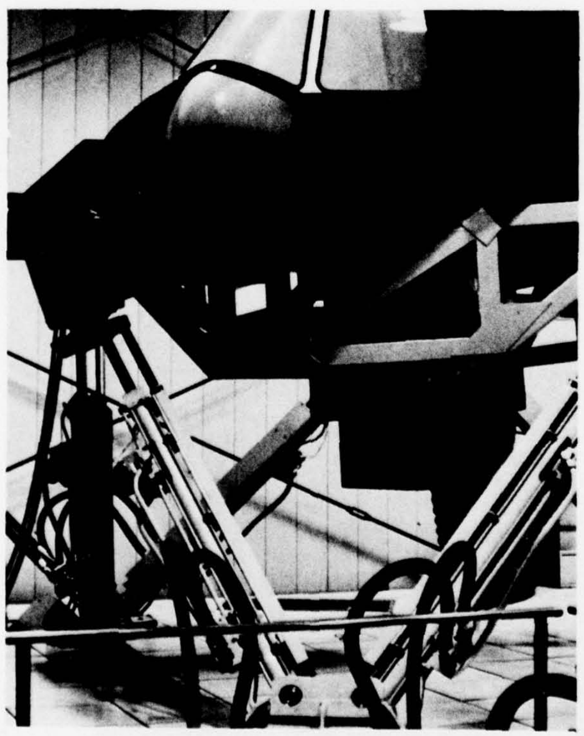


FIGURE 1-4

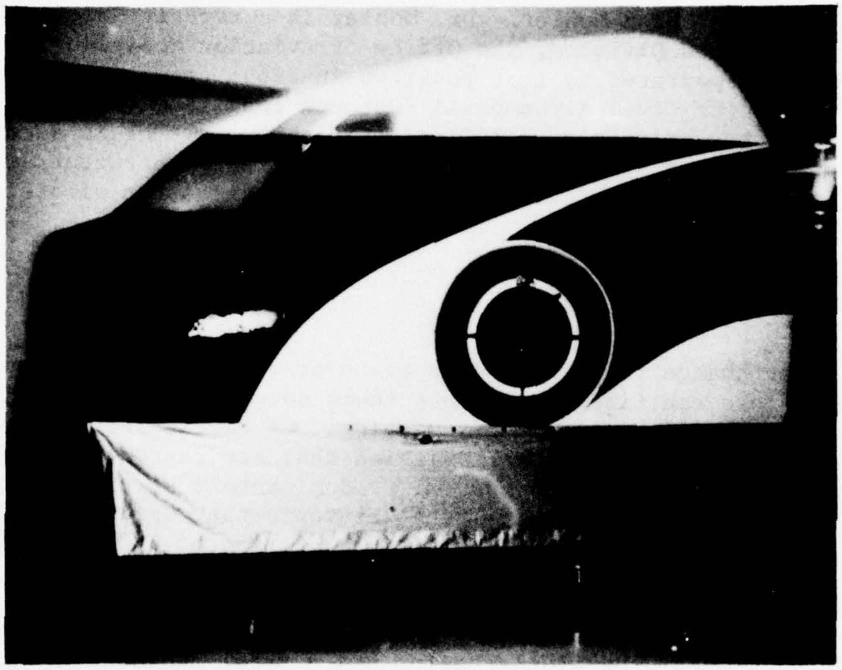


FIGURE 1-5

MEDICAL FACTS FOR PILOTS

MR. JOSEPH DEL BALZO

The next speaker is Dr. Stan Mohler. Dr. Mohler is currently Chief of the Aeromedical Applications Division, the Office of Aviation Medicine in Washington. He was appointed to that position in 1965; previous to that, he was the Director of the Civil Aeromedical Research Institute (CAMI) in Oklahoma City. He has written over 100 scientific papers. He is a certificated airline transport pilot, and a certificated flight instructor as well. This morning he is going to be talking about medical facts for pilots.

DR. STANLEY MOHLER

Good morning. Our charge this morning is to cover with you some recent concepts in medical research findings so that these dovetail with the other research discussions that go on at this meeting. We have selected five topics for discussion that relate to General Aviation that are currently receiving attention in our medical research program, predominantely at the Civil Aeromedical Institute in Oklahoma City. The first topic that we want to discuss with you is the continuing use of alcohol during flight by a small number of pilots. We find this in our toxicological studies of the aircraft accident investigation activities. Each week somewhere in the United States a fatal aircraft accident occurs, where alcohol was involved. And just 2 weeks ago, we were all shocked when a particular pilot had a fatal accident doing an unwarranted low-level maneuver. This pilot had been a very well known pilot, a very capable pilot. As the history is now developing, for approximately 5 years something had been going wrong in the personal life of the pilot. The pilot had begun consuming more and more alcohol, up to the point where this individual could not go through a day without some alchohol. Quite naturally, if you are going to fly and you have to drink everyday, sooner or later, you are going to fly and drink at the same time. We know that programs of self education that are given to pilots can bring about a change in the pilots behavior. There may be some persons who won't change, but there are some who will. That is why this topic dovetails with the preceding discussion of judgment. Can judgment be taught? In other words, can behavior changes be brought about through self-awareness and through training.

Figure 1-6 shows the changes in alcohol-associated fatal general aviation accidents from 1963, which were running approximately 43 percent of the fatal accidents, down to about 22 percent in 1967 as a result of a blitz of pilot education by the FAA. Then there was a slow drop to about 15 percent (13 to 15 percent) of the fatal accidents. We feel this is due to Part 91.11; specifically, the regulation that came into effect December 5, 1970; i.e., eight hours from "bottle to throttle." But we've now leveled off around the 13-percent level. To break that 13 percent level is going to require help

by the pilots. The FAA, I feel, is very likely to take some kind of educational and/or other action in the following months to try to get this 13 percent down. It may be to something like 5 percent or 4 percent that we will never be able get below. But we know that we can do better than 13 percent, and that this 13 percent is having an adverse effect on the overall safety record of General Aviation. There are two items out of research on this that I would like to mention. One is that a person standing on a relatively stationary environment (for example, the earth) does not always demonstrate the subtle but critical adverse affects of alcohol on the balance system. When the person is put on a relatively moving platform, such as an airplane, the balance system clearly demonstrates the adverse effects of alcohol. In a study the FAA funded at Ohio State University, it was shown that one drink of alcohol, in flight, markedly impairs pilot performance. Furthermore, it was shown at the Civil Aeromedical Institute, that even after 24 hours following one drink, overcompensatory changes in eye movements can be demonstrated on a rotating platform.

We feel that these lingering effects of alcohol are playing a role in some of the accidents that have occurred. One other effect is that to fly properly, a person requires a good period of sleep in the appropriate preceding rest period. This is because the human nervous system, for efficient function, must go through a sleep regeneration phase once in each 24-hour period. Sleep is an absolute necessity for good well-being. We can show that alcohol is, let's face it, a type of anesthetic agent. Alcohol does interfere with quality sleep. The alcohol drugged sleep is toxic sleep, and the next day the result is greater proneness to fatigue. In addition, alcohol causes an emotional change in the individual. When the individual drinks the alcohol, the individual feels better. Of course, that is why people drink it. But when the alcohol wears off, one goes through a phase of feeling worse than would likely have been the case otherwise. It is a phase of irritability. This phase may affect judgment as to what should or should not be done during flight. This covers the phase of alcohol research that I wished to cover. I just want to emphasize that alcohol is still a major problem in aviation. We need the help of everyone in solving this problem in the coming months, including more educational and possibly new regulatory actions.

The second topic, figure 1-7 of our research, I want to cover relates to oxygen use. The current regulations in General Aviation require that for unpressurized aircraft, supplemental oxygen be used at 12,500 feet and above. It was found that over the mountainous areas it may be safer for the pilots to be able to go for another 30 minutes up to 14,000 feet without oxygen rather than skimming some of the mountain tops to abide by the 12,500-foot rule. Therefore, the regulation does provide for pilots to go to 14,000 feet for 30 minutes with the tacit understanding that this is to get safely over an obstacle. We know that performance is not as good at 14,000 feet as it is at ground level, because, for example, one can't add and subtract as well at the higher altitude. But for purposes of safety, the 30-minute period at 14,000 feet is acceptable for most healthy pilots.

In order to help pilots, a little known step was taken by the FAA in that, on the IFR planning charts, those airways that have minimum enroute altitudes at or above 10,000 feet, have been printed three times as wide as the other airways, figure 1-8. I believe you can see the wider airways on this chart. If you are going to plan an instrument flight, you may be put on one of these airways, and may need, from a physiological standpoint, supplemental oxygen. We designated the 10,000 foot level for beginning oxygen use because this is wise for a significant number of persons, including heavy smokers. This wide airway designation is a warning to the person that the MEA may be at or above 10,000 feet.

We just want to show you the little air sacs, the alveolae, that the pilot uses to exchange oxygen in flight, figure 1-9. These little air sacs are extremely delicate; they are microscopic, and anything that impedes the oxygen flow in these air sacs will impede the oxygen flow to the brain and the efficiency of the pilot. We have just completed a research project at Oklahoma City where pilots who are smokers were examined. We were quite suprised that the smokers show, on the average, only 60 percent of the capability of nonsmokers to move oxygen through these little air sacs. I recommend that all pilots quit smoking, particularly cigarettes, because smoking definitely does impair the oxygen flow. A nonsmoker at sea-level, sits beside a cigarette smoker, figure 1-10. The smoker is physiologically at 7,000 feet because of the blood carbon monoxide level. Seven thousand feet is the altitude slightly above which night vision is impaired. This is another reason not to smoke. Your night vision does get impaired with lower levels of oxygen in the blood. When the nonsmoker is at 10,000 feet in his unpressurized aircraft, the smoker is at 14,000 feet. That is why we say definitely smokers should start using oxygen in unpressurized aircraft at 10,000 feet.

I wanted to touch on the aspects of aging to a certain extent, and I will focus mainly on the eye, figure 1-11. The human eye, at somewhere around the age of 40, looses the ability to have the lens, which is shown in the center, here, capable of forming a sphere. You need that sphere to accurately focus light on the retina from near objects. The retina is the part necessary for vision. In figure 1-12, you will see a picture of this lens. I want to show you this just to illustrate how complex the human lens is. It is made of at least a dozen different types of fibers and structures, and we start out able to see very close, within 2 or 3 inches of our eye. Watch some very young person, and you will note that he or she can see tiny objects, unarrested, held very close to the eye. But from then on the lens of the eye starts aging. And even by age 20, the near point of vision has moved out to about 7 inches, perhaps. But by 30, it is out to 12 or 14 inches. When you hit 40, you will likely have to have bifocal lenses. Usually, this becomes absolutely necessary. In our FAA approach, we have not concentrated on near vision for the general aviation pilots under contact navigation type circumstances. As a matter of fact, we don't have a near vision standard for our class 3 medical certificate. We may have to rethink this as time goes by, because more and more general aviation pilots are using instrument approach charts.

I do want to stress that general aviation pilots, in the process of upgrading themselves, must be aware that somewhere around 40, especially under reduced light conditions as at night, will find small print difficult or impossible to read. The critical information on the instrument charts may be illegible. This is an aging change that is absolutely correctable. Here you see, for example, a far-sighted eye, and this is typical of what we experience when we hit middle age, figure 1-13. We can see things in the distance better than we can up close. Notice that the image is focused beyond the retina. The next illustration shows a perfect correction with the lens for reading, and this is one aging change that is 100-percent compensated, figure 1-14. The change is, however, insidious, and sneaks up on the individual. We're certain that some confusion has occurred at times in cockpits, because a pilot hasn't realized that in the dim light at night he couldn't read the charts. Fatigue may be an aggravating factor. I want to emphasize that for high-quality vision in the daytime you need central vision, which only covers a very limited arc, figure 1-15. At night you are using peripheral vision with very little capability to see exactly in the center of the eye under true dark night conditions. You should, at night, when looking for other aircraft, look slightly to the side of the point searched. This has been known for many years, but it is a factor of significance to collision avoidance. Now, the last illustration I want to show you, is one that was made at the Civil Aeromedical Institute some years ago, figure 1-16. The reason I want to show it to you is that a new regulation for General Aviation has taken place, effective July 18, 1978, FAR, Parts 23.785, 91.7, and 91.33. Civil aircraft manufactured after that date, covered in those regulations (unless there is some peculiar reason, and these reasons will be very few), must have shoulder harnessess, and the pilot must wear the shoulder harness during takeoff and landing. The reason I mentioned this is that in our accident investigations we find that over half of the current fatalities could be prevented if pilots (and front-seat occupants) had a shoulder harness available, and had worn it. The main cause of death in these general aviation crashes is the flexion of the torso of the body around the seat belt against the control wheel and the instrument panel. The human takes a great deal of impact force but cannot take puncture wounds and sharp penetrating wounds. So I want to stress: wear your shoulder harnessess! Starting in 1 year, these newly manufactured civil aircraft will have the shoulder harnesses. That concludes the main topic that I have to present to you today. Thank you very much.

GENERAL AVIATION FATAL ACCIDENTS

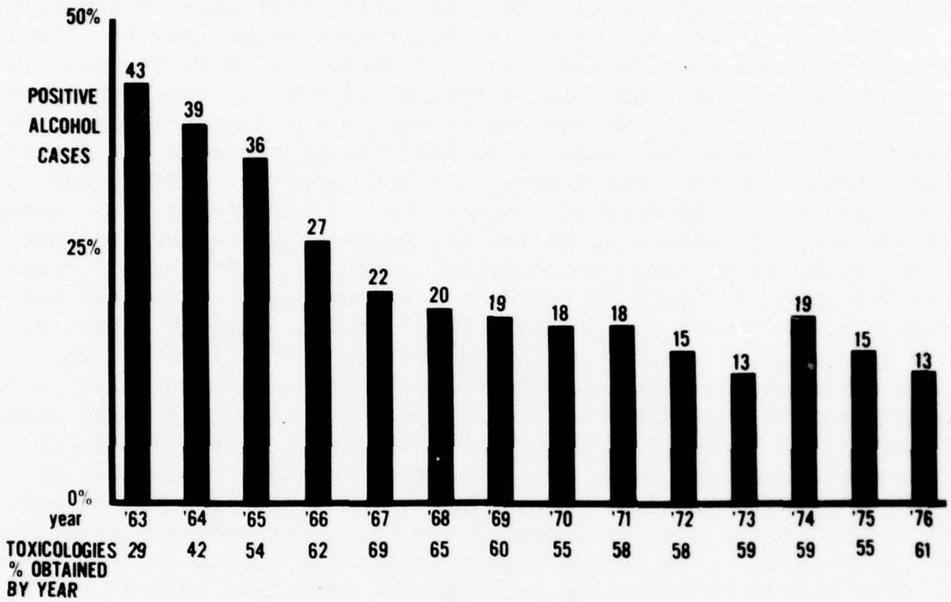


FIGURE 1-6

SUPPLEMENTAL OXYGEN
FAR 91.32

USE O_2: CABIN PRESSURES ABOVE 12,500 FEET MSL

EXCEPT

UP TO AND INCLUDING 14,000 FEET MSL
FOR 30 MINUTES
(TO GET OVER MOUNTAIN)

IFR PLANNING CHART - AIRWAYS 3 TIMES
AS WIDE IF MEA AT
10,000 FEET MSL OR HIGHER

FIGURE 1-7

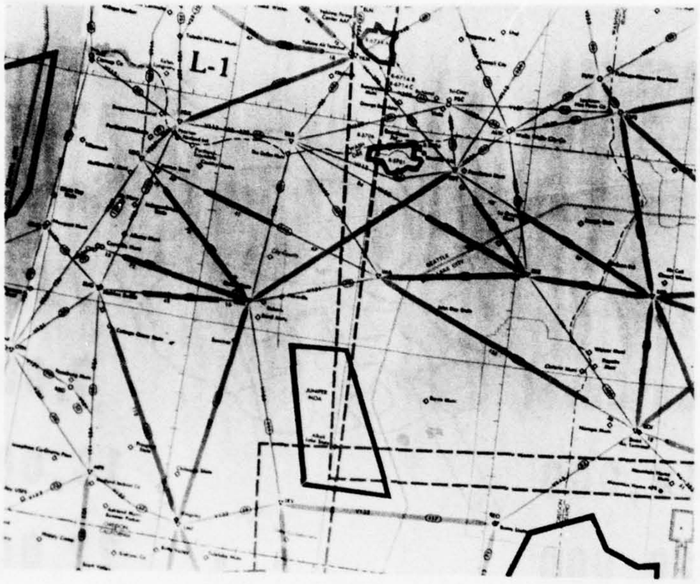


FIGURE 1-8

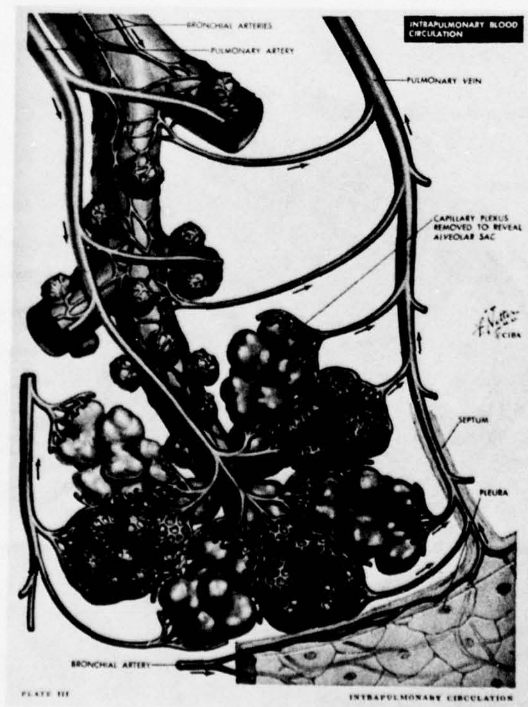


FIGURE 1-9

ACTUAL ALTITUDE (Non-Smokers)	APPARENT ALTITUDE (Smokers)
FEET	*FEET*
Sea Level	7,000
10,000	14,000
20,000	22,000

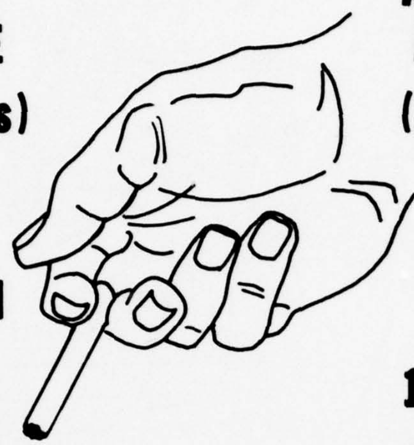


FIGURE 1-10

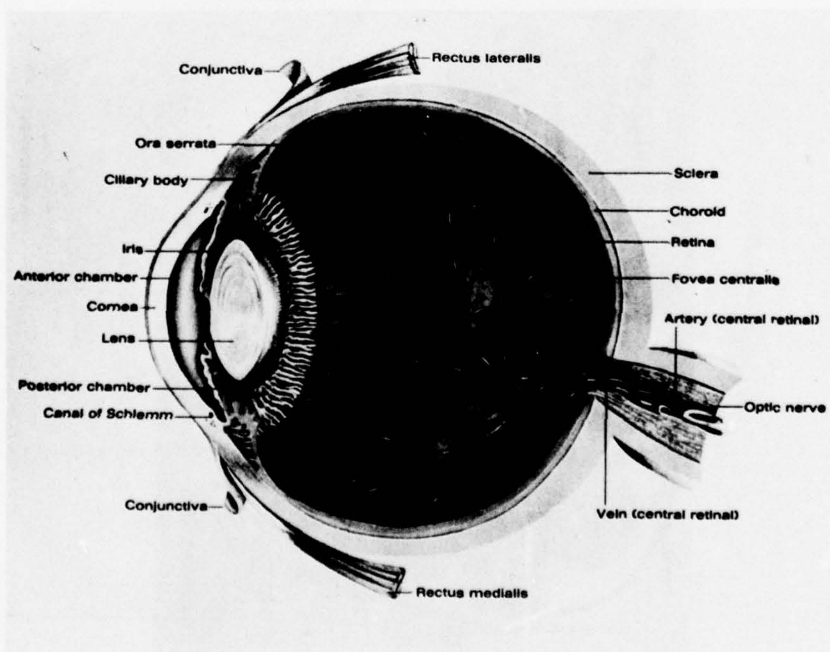


FIGURE 1-11

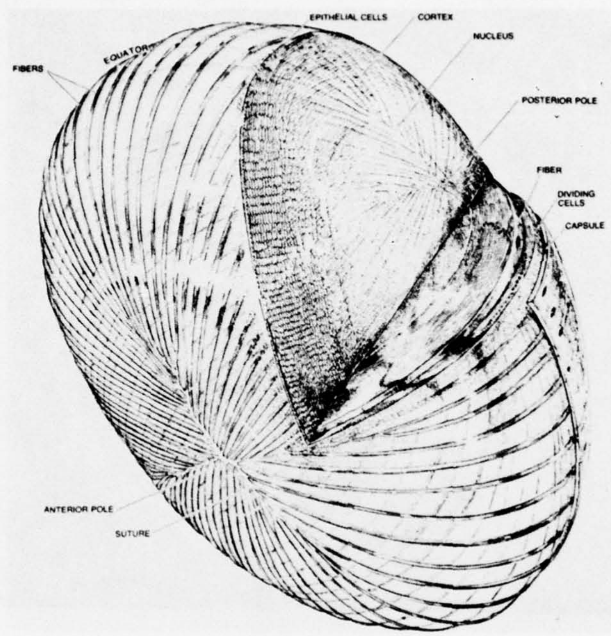


FIGURE 1-12

FIGURE 1-13

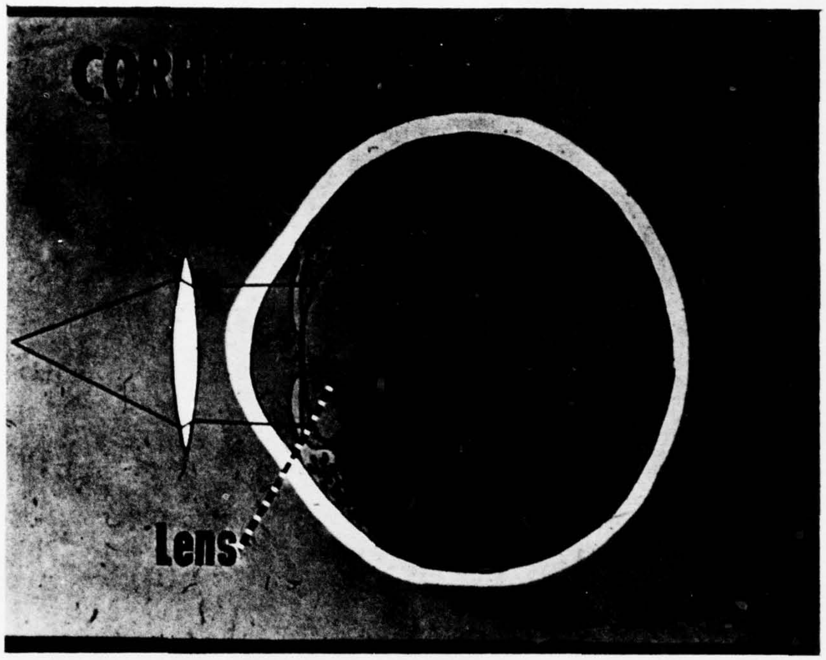


FIGURE 1-14

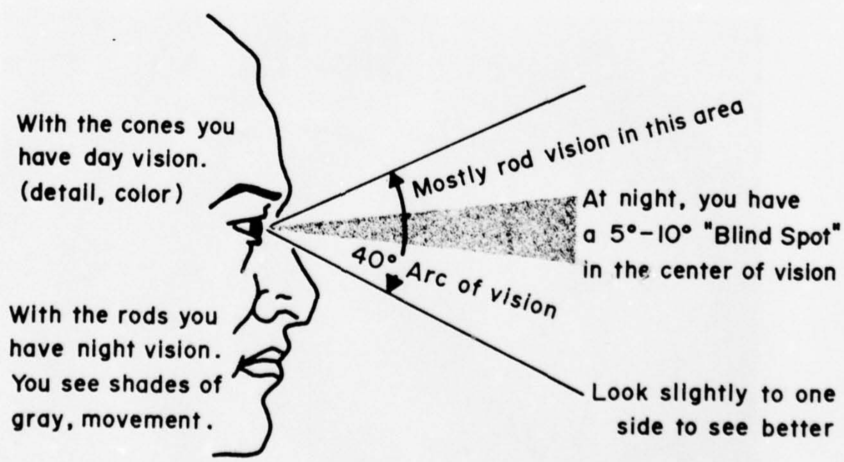


FIGURE 1-15

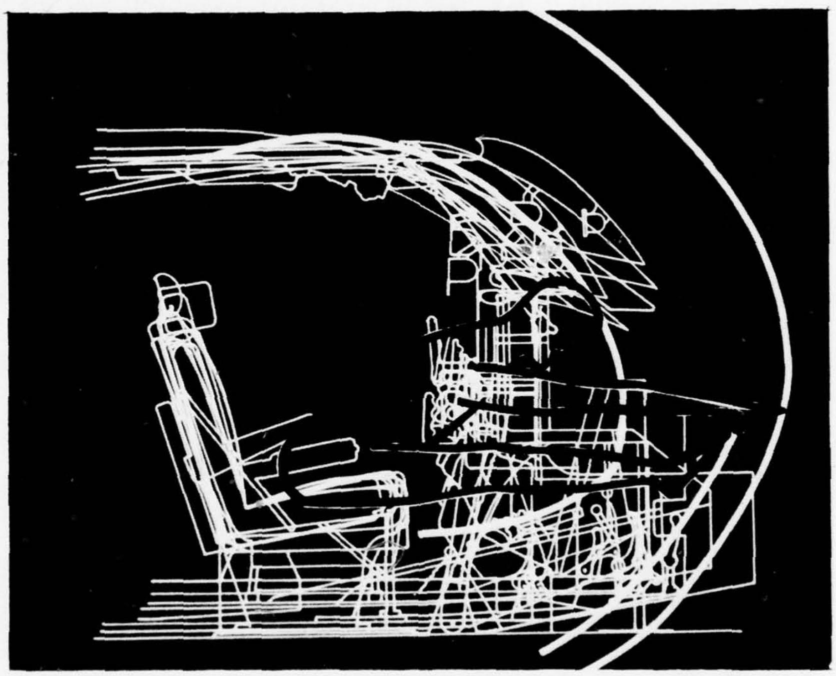


FIGURE 1-16

STALL AWARENESS TRAINING; PILOT IMPROVEMENT
TRAINING; POTENTIAL FUTURE WORK

MR. JOSEPH DEL BALZO

The next speaker is Pat Russell. Pat has 10 years of aviation R&D background behind him with the Systems Research and Development Service in FAA Washington headquarters. He was a pilot in the U.S. Navy for 27 years. His remarks this morning will focus on four projects which bear on the subject of civil pilot training.

MR. PAT RUSSELL

Good morning, I am glad Joe didn't mention the Navy first. I didn't know Jimmy Riddle had been in the Navy. He must have been the safe guy; I was the dangerous one. That is why I am so happy to be in this business. I am learning more everyday.

Of the four projects I would like to discuss this morning, two of them are current. The other two are potential future efforts. They have not been approved as yet.

Our most recent project (which has been completed) I would like to discuss now. It is the Stall Awareness Training Project. The number one recommendation of the NTSB Stall/Spin Study was that we look at innovative methods of eliminating, or at least helping, in the stall/spin problem. The Stall Awareness Training Project was conceived in response to that recommendation. I won't go into a litany of statistics on the stall/spin accident rate. We have already been frightened enough by Dr. Mohler. What I will indicate in my remarks is that we are addressing the problem. In this project we conceived a very abbreviated ground school, which is more comprehensive and intensive, especially in the area of aerodynamics. The pilots were volunteers, whose experience ranged from 10 hours up to 170 hours. They were located at two approved flight schools in New England.

A second method for improving their performance (beyond the ground school) was a far more comprehensive stall training syllabus. About 2 hours or more of solid stall training, oscillation stalls, aggravated stalls, cross-control stalls which is many more than the ordinary control syllabus, (of the approved flight school) would require.

A third and last experimental syllabus increment was the spin training, which only consumed one-half hour. It involved oscillation stalls, some of which can be vicious, and spins, left and right, demonstration and recovery by the student. These students, as I indicated, were all volunteers. The control group simply went through the approved flight school. They were examined,

with quizzes separated by a short interval. The other groups were given the quizzes before and after their ground school. The second experimental group had both the ground school and the stall training, while the third experimental group had the ground school, the stall training, and the spin training.

I would like to discuss the evaluation flight. How do you get an objective evaluation flight? We tried to be as objective as possible by constructing a flight in which we had a video recorder aimed at the instrument panel, and a recording system for documenting the comments of the flight evaluator. These then were played back and became the source of the data for the background. You might be interested in the evaluation flight. How would you like to fly around 5 knots above stall for 1 hour and 30 minutes with the stall warning indicator on? If the stall warning indicator goes off, you are too fast and you are going to get a black mark. If you go into a stall you are too slow and you are going to get a black mark. Just flying straight and level at those speeds is difficult enough to do (I have tried it myself and can attest to the difficulty). In addition to maneuvers, students were expected to perform tasks, climbing and gliding turns. They had to navigate, read charts, communicate, change frequencies, drop their pencil, pick it up, and locate specific landmarks on the ground. These were the test programs. The results are as follows: All four groups improved. That was to be expected. Just the transfer between evaluations could provide <u>some</u> improvement. That included the control group, of course, also. But more improvement was experienced by all three experimental groups than in the control group, which could have been expected. The grades on the ground school exams do not correspond with the grades on the flight exams. I guess we have known that all along, haven't we. You know dumb pilots sometimes are good pilots. And good pilots---well alright, leave it at that. The experimental-ground-school-only group, which received just the ground school with no extra flight, stall or spin training improved the most. Now what does that mean? Well it could mean that they were less capable than the others at the start, and therefore had more room or leeway for improvement. We only had 55 students. I wouldn't want to bet my life on the statistical validity of that small sample. That is the reason why we want to look at these people for the next 3 years, bring them back for biennial reviews, and then go ahead and run the evaluation flight over again and see how they look. We, at that time, may be smart enough to say that a particular type of training will be superior, and will create a pilot less likely to stall and spin.

The next project I would like to discuss, we have not really instituted yet. We are into the negotiating phase right now. It has a short title: Civil Pilot Training Improvements. It means, lift yourself up by your boot straps. We want to take a whole, hard look at all civil flight training. We want to see if there is a better way, by using different equipment, simulators, sailplanes, better ground schools, computer aided education, whatever it might be, to formulate methods by which we can produce pilots in the future---1980's and beyond---who will be able to operate effectively in the more constrained, more demanding environment which we expect to evolve. The objective is, as I say, to provide such pilots. The method of approach is to canvass all of flight training-- United States and foreign, civil and military, flight and

ground. Now, to anticipate a question, somebody might say: Why are you going to look, for instance, at the military? I mentioned that I would look at the military flight training, not only in this country, but also overseas, to determine if there are better ways of training pilots. We know that the military pilots go on and get maybe 300 or 350 hours of training flight time, and we can't talk about that for private pilots or even commercial pilots. But we are thinking, in the primary phases of flight training, there may be methods of doing it better. We want to end up with people who do not stall and spin and do not fly in the clouds without the capability of getting themselves out again. These are just two of the areas we can look at immediately.

To postulate a future environment is not too difficult. We have done it before, although, in truth, we have had to reevaluate our numbers at intervals. The FAA, I believe, can accomplish this task. Our management services people have a solid capability in this area. Also, the things you will be learning in the next couple of days from other presenters concerning the equipment and the air traffic control system should indicate what that future environment will be. Under contract, we will develop an experimental flight training syllabus, or a number of flight training syllabus increments, and then test them on a statistically valid sample of volunteer students. We hope to get more than 55 in this case. By the same method used before, we will use the 3 year evaluation phase with these students to determine how much they improved, and whether they would be able to operate in the environment. The product of this work would be recommendations for future use. If the flight training programs are to be changed in the future, hopefully, we will have data like this to support such changes.

Now, I would like to discuss potential future work. About 3 years ago we did some skill degradation work at MIT with noninstrument rated private and commercial pilots. As a result of that work, we determined that their instrument capabilities and their stall demonstration and recovery were poor. But, I want to limit my remarks to instrument skill degradation right now. Since these were noninstrument rated people, their lack of instrument flying proficiency would not appear to be critical, although there are, as you know, many accidents where people who are noninstrument rated do get into water over their heads. However, since instrument rated pilots are responsible for a percentage of such accidents, we plan to look at the instrument skill degradation rate of this pilot category. We all know that we have people who flew yesterday on instruments, and some who have not flown in years. Where are they the weakest? In what particular part of the flight regime on instrument conditions are they the weakest? If we can spotlight those areas and bring these pilots up to speed, we will have accomplished much in this program. But our basic purpose is to develop better ways of teaching instrument flying and maintaining proficiency.

The last effort which I shall discuss is simply a study. The information I am about to present is the result of a survey which took place as part of our Stall Awareness Training project previously discussed. We surveyed 75 flight instructors at a flight refresher clinic, and these are the results of that survey. At the time of that survey, 3 years ago, I did not have this project in mind. How many teach spins? I am surprised. Thirty percent of them teach

spins. Maybe you would be surprised that 65 percent think spins should be included in the syllabus. There must be 35 percent that would like to see spins taught but they don't want to teach them. We don't know. The rest of the data I do not think are that surprising, but it does show that people are thinking about spin training. Not only the instructors, but also the students. How to proceed? Simply to study the accident history in relation to the regulatory history. You know, we eliminated spin training in 1949. But as a corollary to that, of course, aircraft have changed since 1949. Very few aircraft are now certificated for intentional spins. Therefore, that is a part of the study also. The accident rate, as we know, is only one-half of what it was back in 1949. This indicates that we have been going in the right direction somehow, but how can we cut it down further? That is what we are looking for. We would like to look into the economics of spin training. How many schools would have to purchase additional airplanes in order to reintroduce spin training? That number certainly would affect the economic position of the FBO's and the flight schools.

Psychology is a long word for fear. How many people are afraid to spin? I am afraid to spin. I think if all of us would be honest, we are afraid to spin. But if we really looked into our hearts we would say if we ever get into a spin it would be nice to know how to get out---wouldn't it? And these spin accidents always happen. They never happen without first experiencing a stall, and that is why the FAA is currently concentrating on the stall. We have high hopes for these projects. We think they are going to provide solid impact on flight training of the future in the civil area. Thank you very much.

A GENERAL AVIATION USER RESPONSE TO AIRMEN R&D PROGRAMS

MR. JOSEPH DEL BALZO

So far this morning you have heard from three FAA representatives on the subject of civil aviation airmen. They have talked about the results that have been achieved from tests and research projects. They have talked about some ongoing research work and some proposed potential efforts in the future. We would like to change pace a little bit now and listen to the users side of the general aviation community. Hopefully, what we will hear is some reaction to an R&D program for civil aviation airmen. The first speaker is Jack Eggspuehler. Professor Eggspuehler is chairman of the Department of Aviation for Ohio State University. He has been a professor of aviation science since 1958. He is a former member of the board of directors of NATA, and he is president and founder of the National Association of Flight Instructors.

MR. JACK EGGSPUEHLER

I was delighted to hear the Administrator suggest that FAA's posture in the next 2 years, as far as R&D is concerned, would be one of support, and in this supportive role, I think we will find that we will be carrying the benefits, the many benefits, of an R&D program throughout the many universities and research organizations in this country. One of the most beautiful aspects of this is that it will get young people interested in the problems in aviation. And by placing the research problems in the institutions of higher education, these young people have an opportunity to see and appreciate these problems and then dedicate themselves to doing something about them. So I applaud the Administrator's position on this.

Becoming more specific, as far as some of the things we talked about this morning, Jim Riddle's position on ground pilot trainers and training for pilot judgment improvement stimulates a few observations that I would like to share with you. First, with the rapid changes in the aeronautical environment, which are occurring daily, there is reason to believe that corresponding changes in training techniques and equipment are imperative. I hope that from the users standpoint we will recognize that we need innovations in training procedures and devices. Pat Russell has just indicated that work is being done in this direction. But we need these innovations to improve the effectiveness of training without increasing the amount and particularly the cost of training.

I noticed in Jim's presentation that we are talking about evaluating and measuring judgment. Although research would indicate what we already know; I think we all recognize that this matter of judgment comes from a variety of experiences, and I personally have a great conviction in this regard. Those who attest to the fact that some can make an instant, most brilliant decision in the air and extricates themself from an emergency situation, I think are deluding themselves. I think really what takes place as far as judgmental qualities are concerned is that we in the training programs do a good job of exposing

these people to a variety of experiences from which they can draw when they are faced with the task of making a good judgment. Therefore, I hope that our research will embrace this whole area of training people with a variety of experiences. In fact, I am not beyond taking people out, in the primary stage of pilot training, and exposing them to problems of scud running. Now, I know many people say that's heresy; "What are you, some kind of nut?" Well, I beg the question, how many people have ended up doing a little scud running? And I think one of the most unfortunate aspects of this is that the first time someone does some scud running it is at a time when he is scared, when he is low, when visibility is extremely poor, and when he is in a situation of extreme apprehension and stress. And given those conditions, we do not think well and we do not respond well to some of the tasks that are put before us. Well, I urge that in whatever research we do in this area of developing judgmental qualities on the part of our pilot population, that we make an effort to have it be very realistic. Whatever basis we have for this training, we must realize that these teachings will be the teachings starting off from the little fixed base operator in Timbuktu since he may not have all the sophistication of the equipment that we enjoy in institutions of higher education.

On the other hand, the equipment, no matter how well designed, will be useless if the instructor is not well suited and indeed prepared to teach effectively with this equipment. Too often we come up with these great ideas about what will work, but we do a poor job of preparing those who must teach with this equipment and work with the students. I like the idea, of training to a standard. As a matter of fact, I appreciate suggesting that we give credit to ground simulation equipment or ground trainers and simulation equipment for their role in meeting this standard.

I would again hate to miss this opportunity, once again, to suggest as part of a campaign that I have been on for some 20 years, and that is to do away with all hourly requirements as far as pilot certification is concerned. I frankly think that it is detrimental to the whole process of pilot certification, that we suggest that a certain number of hours will meet the standard. We know that is not true, and we know that whatever hours that we have right now are not consistent with the real world number of hours required to meet the standard on the national average. Therefore, I say to you, let's do a good job of defining the standard of pilot certification at all levels of certification and then let's teach to those standards and assure in everyway that we meet them. In this way we can avoid the psychological constraints working on people who say, "Gee I took 90 hours to get my private pilot certificate, I must be a failure." Not necessarily. If you meet the standard at 110 hours, you are a success.

Turning to Stan Mohler's presentation, a guy whom I appreciate so very much. You know, I spent a great deal of my life preparing people to pass written examinations; private, commercial, instrument, and ATP. As part of that program we have a very, very favorite expression that we got from Stan Mohler. The night before the people are going to take their written examination, whatever it is, you have some idea, I am sure of how apprehensive they are. You know a neurosurgeon is reduced to the mentality of a 5-year old the night before he is going to take his written examination, right? Well, we asked Dr. Mohler,

"Stan, tell us, what should we tell the people in our classes the night before they are going to take the examination?" Being a clean liver that he is, Stan Mohler said, "Well, here is what I would tell them, I would tell them, have a good meal, get at least 8 hours of sleep, absolutely no drinking, study of course, try and keep the smoking down, in fact, don't involve yourself with it if you can avoid it. Then he added, "and if at all possible, try to have a pleasant experience." Now, I dont't know what he meant by that, but he does know, I think, how to reach people.

Well, we agree with you, Stan Mohler, on the matter of alcohol. There is no question about it. In our society we have come too often to accept alcohol as a way of life. My wife who teaches in a high school near the Columbus, Ohio area is appalled many days to see 16, 17, and 18 year old students coming into classes drunk or otherwise incapacitated by alcohol. This is a very well-to-do area, where 90 percent of the high school population goes on to college. It is nothing for her to see, many times, students come in drunk to class. Why? Because the folks do it, why can't we? I think we do have some things to change there, and we have got to make people realize the significance of using alcohol near or during the time of flight.

In regards to vision, I think probably, pride more than anything else, is the greatest enemy as far as vision is concerned. Where are my glasses? But now I can't see my notes, so I will have to take them off. Yes, pride does get in our way, but it shouldn't. There is nothing wrong with having some glasses around, especially when you are going to fly, and you have got a small audience then so it doesn't make any difference. But I have to add, Stan, that it is not my eyes that I am worried about. I am far more worried about certain physiological results of that aging process other than my eyes. So whatever help you can give in that area I would certainly appreciate. That also happens around 42, Stan.

The other area of research and development I applaud is the shoulder harnesses. When I joined the faculty of Ohio State University as Chief Flight Instructor, I was quite taken back by the fact that our supervisor of aircraft maintenance had shoulder harnesses in every one of our training aircraft. The reason for that was that he had been in agricultural aviation and he had seen first-hand the results of using shoulder harnesses. To make a long story short, let me tell you we have had two very serious accidents involving the training program. One, whereby, a very eager young pilot instructor was demonstrating an emergency landing, did indeed get too low, caught his landing gear on some high wires, and caused the aircraft to strike the ground full impact at approach speed. The aircraft then, after impact, rolled onto its back, and it took the impact dead on the instrument panel. There was a young lady and the flight instructor in the aircraft. Well, when we got to the scene of the accident and found both of them walking around with only bruises on their shoulders, there was never any question in my mind about the role of the shoulder harnesses. I applaud what you are doing because it unquestionably will save lives. It will save many lives in General Aviation.

On stall awareness, most certainly we can become more innovative. I think we paid far too much attention to the recovery from stalls and to the recognition of where we are with this research. What we are doing in the innovative process of stall awareness, it has been a long time coming. In the potential future, the bienniel flight review should absolutely place more emphasis on the demonstration of instrument capability for private pilots. I agree that there are decrements of performance in this area.

Through the years there have been various efforts to inventory and validate the elements of pilot training programs. A series of research efforts has been sponsored by the Federal Aviation Administration to explore specific questions dealing with pilot training effort. These innovative efforts and the potential in some of these research projects were often compromised by the existing standards. Many times we let the pilot certification standards enter in, and affect some very innovative programs that could have been undertaken. While great encouragement was given to the innovative process, the standards of regulatory form tend to overly control and greatly influence our efforts in research. The present flight training programs throughout the United States are still largely a function of the traditional methods handed down through the years. While they are strong in many areas, the question remains, are the present flight training methods adequate, and are they effective in meeting acceptable safety standards in the needs of today and tomorrows's airmen?

Probably one of the most effective means of improving pilot training is to upgrade and preserve the professional flight instructor. We need to communicate the ideas that come from a forum such as this to every flight instructor who is active in this country. History points out that the lack of commitment on the part of too many flight instructors in carrying out their teaching responsibilities is detrimental to our industry. This, in large part, results from an instructor's view of flight instruction as a means to an end. We as an industry must view the professional flight instructor as a great asset to our industry. Programs to improve the role and the lot of the flight instructor would be a significant advancement to basic pilot training.

The lack of standardization in pilot training is also a serious threat to improving flight training on an individual basis as well as to flight schools. One of the more effective means to meet this need could be a creation of a proven, effective pilot training syllabus. Such a syllabus, with ample guides to the instructor, not necessarily restricting his innovation and creativity, but giving him guidance, would be greatly appreciated by every flight instructor in this country and every airmen who will be flying in the future.

A GENERAL AVIATION USER RESPONSE TO AIRMEN R&D PROGRAMS

MR. JOSEPH DEL BALZO

The second user response comes from Jim Pyle. Jim has an extensive background both within and outside of government, and I am sure he is well known to all of you. His government background includes Special Assistant to the Assistant Secretary of the Navy for Air. Best known to people in the FAA as the administrator for the old CAA, he is a former Deputy Administrator of FAA as well. His private background includes a stint with Pan American Airways, president of an air charter company, and vice-president of General Precision Incorporated. He is an ATR pilot and is Director Emeritus of the Aviation Development Council.

MR. JAMES PYLE

Thank you very much for that introduction. You forgot to mention that I was president of a laundry that went broke in Denver. For any of you guys here from Denver, I will see if I can find your shirt. Jack Eggspuehler is a hell of an act to follow. I think I should just say "Amen" to everything that he has said and sit down, then we could get into the questions and answers.

But as an ex-bureaucrat I can't resist, with a microphone in front of me, to say a few words. First, I have a little nostalgia coming back here to NAFEC, because I well remember that hot July day when the Navy handed over the keys to this facility to Pete Quesada. I, for one, think that was one hell of a good buy, because it has been a facility that has really made its mark in aviation progress throughout the world. I remember well, about 5 years ago in the cockpit of a Pan Am jet coming into Moscow that we broke out at about 300 feet and there was the NAFEC configuration right in front of us. I suppose the Russians invented it first, but as far as I am concerned it is what we did here at NAFEC that was the secret of that international standard for airport lighting; and incidentally, I must give credit to the British for their contribution to that important work.

Second point I would like to make is an enthusiastic "good show" to the administrator's words this morning, and to his obvious interest in General Aviation. This is heartening. I think it is great, and as I told him on his way out, if there is any way that I can help in that area of his responsibilities, having been somewhat familiar with them (probably gray-haired as a result of them), I would certainly like to pitch in. I commend the FAA for putting on this conference because I think it's high time that we establish the best possible communication been the R&D effort and the users---all of you out there and those whom you may represent. Now, for a few comments, and I am going to try to just tick them off real quickly, because I think the important part of this exercise is the question and answer session. With respect to simulators, Jim, I have a semantical quarrel with you only that I think the use of the word simulator is somewhat misleading. As far as I am concerned they are synthetic or procedural trainers, and that in no way derogates their function. But to call it a simulator is questionable, because they do not actually simulate anything but an envelope, a flight envelope. I happen to be the guy who bought

the first 707 simulator, and if you had known the trials we had in getting that thing certificated down in Oklahoma City, I think you would understand what I am talking about. Synthetic trainers are most useful devices. Let's not forget, we have an energy crisis; let's see if we can't put that particular device to work in saving some of the training fuel. It is important; we in General Aviation need that fuel desperately, and if we can save just a few gallons, by God, let's do it. Secondly, I think in your program, Jim and maybe Pat, you ought to think about the use of the simulator, or synthetic training device in the biannual flight review. I personally think that this is a hell of a good program. But, I have the good news and bad news department. I had one very good biannual flight review and one that I thought was lousy. For example, the whole flight review consisted of slow flight. Well, I fly a Navion now, and I am very used to slow flight, so that was his idea and in certain categories this is probably very important, but I question it in my case.

In the area of judgmental training, I don't know how we do this and I am delighted to see that this is being attacked by the FAA. But somehow, we need to fold into that judgmental area, the whole question of weather hazard and how you can cope with it, and what things are significant. I like your idea of scud-training or scud-running. I think this is terribly important and it is a challenge as to how you do this. I am not a physiological or psychological type, I will leave it to you experts in the FAA. But try to crank in, among other things, the whole weather problem, because that has killed a lot of people, unfortunately, and we ought to look at it.

I would like to commend the effort, Pat, that you are heading, and that is the whole area of stall awareness in its most sophisticated way; but let's not back off from the spin. I think it's a shame that they knocked this thing out. Sure, I didn't particularly like it when I was a flight instructor to have to go out and twirl around maybe 30 or 40 times during a day, but I think your student comes out a better product by virtue of this and I don't think it should be eliminated. I realize now that we have backed away from it, since it imposes a problem for the flight school; and maybe it should be a phased thing or get one piece of equipment that is approved. But let's get her back in provided there is good rationale and that Jack Eggspuehler's troops and others agree with it. I think it is important that this be discussed openly and if possible be brought back into the flight training curriculum. It presents a problem, I am well aware of it, and part of it is economics.

I am very interested, Stan, in some of the points you make. As I warned you, I am going to get into one area which is a very personal one. But I was particularly interested in the effects of oxygen. Don't overlook this. I am sure many of you, as old and experienced pilots, are well aware of it. But in your training, let's be sure that the pilot recognizes what happens to him. A flight at 8,000 feet affects your judgment when you start down, particularly if you go into a dense terminal area. Let's be sure that you rehearsed not once, but twice, what you are going to do and what is your missed approach procedure. You tend to get careless---and this can spoil your whole day. I suppose I could make a confession---it's supposed to be good for the soul. But Stan, is it not a fact that if you are living in Denver, at about 6,000 feet, you are acclimated to a point, and can take on a higher altitude without as much penalty as those who live at sea level? Well, I will have to confess that I used to take photographs at 21,000 feet in a special airplane without

any oxygen and I always got back (I don't know if that proves anything, but the point is that we were living in Denver and I do not smoke and that possibly was part of the thing). The other was I did not realize how stupid I was. Okay.

With respect to vision, one minor problem that I think should be looked at regarding the standards that we ask of the various pilot groups. I have, because I am older than Eggspuehler, bifocals, which I have to wear, both for distance as well as close-in correction. But the close-in is not the right correction. It's all right for reading approach charts, but what do you do for your instruments and for those things that are a little further away. And and when you get into a big cockpit like a 707 or a 747, you've got things that are even a little farther away than that---that you have to read. You don't want to pull the circuit breaker on the wrong thing. So it is very, very important that we think a little bit about that intermediate distance correction because I think, particularly as you get older, you have to be able to accommodate to a number of different distance situations.

Now, let me just get on to one subject which I would like to end with, and that is this whole question of the aging process. I happen to be, and if there happens to be any airline pilots here, the buzzard who signed that age 60 rule. And we did so with a very specific intent. We had to get, somewhere, a cutoff date, and it was arbitrary and so acknowledged. I think, even in a court case today, ALPA instigated right away. I will tell some of you later, off the record, some of the discussions I had with some of the top ALPA people on that thing---we were definitely making an arbitrary judgment. The tragedy was we had no other basis on which to establish a cutoff date. And I would hope that the FAA would somehow, and I don't know how you would do it, find the physical age of the pilot, not his calendar age. In fact, I did not sign the rule until the preamble was revised and stated that the government had an obligation to establish some criteria whereby we could come up with the right cutoff date. The calendar date is not the right way to do it. And I would hope, Stan, that you and your cohorts could work on that problem. Now this is a general aviation group, and as you know, the cutoff date only applies to the airline pilot. I think this is going to eventually, someday, have to apply to the general aviation pilot. Somewhere along the line, you have got to quit, because you are not capable of handling the situation. I am not sure I am ready to take that test yet, right now, because I might deprive myself of flying. However, it comes to me very forcibly because I have a mother who is 90 years old and still drives a car, and all I can tell you is that when I am on the roads of Maine and I see that blue Buick coming down the road, I head for the weeds. She should not be driving. We have pilots that perhaps should not be flying. And you know the irony of this whole thing is that the deaths in the cockpit---and, Stan you can correct me---are almost entirely in the 48 to 53 bracket. Age 60 has nothing to do with it. So there is a paradoxical situation, and I think research is the way to get at it. And I think it has an application in the general aviation community downstream, after the necessary groundwork has been done.

I am through, and thanks again to the FAA for having this very productive conference, and if there is anything any of us and our various organizations can do to be helpful on an ongoing basis, I think you know we are interested in working with you.

AIRPORT PROGRAMS

MR. JOSEPH DEL BALZO

We are going to change pace again, and talk now about airport R&D programs. The first speaker, who will be from the FAA, is Vic Dosch. Vic is Chief of the Airports Branch at NAFEC. He brings with him an extensive background in R&D programs for airports, particularly focusing on General Aviation. He is responsible for all of the R&D program efforts at NAFEC in the areas associated with airport ground guidance and control, friction grooved pavement, airport lighting and marking, visual guidance, and airport terminal weather. Vic will cover FAA's R&D program in the airports area for General Aviation.

MR. VICTOR F. DOSCH

This presentation will cover FAA R&D airport programs for General Aviation, figure 1-17. When I speak of General Aviation, I am thinking primarily in terms of the single-engine aircraft up to and including the light twin aircraft. Of the approximately 13,000 airports in the United States, over 8,000, or approximately 60 percent of all airports, are turf or unpaved. Many of these airports have little or no marking or lighting whatsoever.

Most of these airports fall under the cognizance of State Departments of Transportation, who are increasingly becoming more concerned about the safety aspects of these operations. Some states are licensing airports, and consequently, are concerned with lighting and marking to achieve standardization and maintaining a standard of safety.

Approximately 2 years ago we were asked by the New Jersey Department of Transportation to assist them in some problems they had in reference to turf runway operations, particularly concerning obstruction clearance and marking of displaced thresholds. As a result of this request, the FAA initiated a Turf Runway Program. The objective of this program was to develop low-cost aids and to come up with recommendations for marking and lighting of small general aviation airports, and in particular, turf airports which would provide a basis for recommendations for the issuance of an Advisory Circular. This program is being performed with the cooperative assistance of the Departments of Transportation of several of the neighboring states, including New Jersey, Pennsylvania, Delaware, and Maryland.

In an attempt to provide a systematic approach to the problem, we began by determining what the functional requirements are for the marking and lighting of small airports. We came up with the following functional requirements shown here, figure 1-18.

We established an experimental turf runway (3/21) at NAFEC for the purpose of testing various forms of lighting and marking for turf airports. Initially, we tested the general type of marking used at many of the current airports,

such as painted aircraft tires, white buckets, corrugated plastic sheets roofing material, and yellow plastic cones. While all these materials appear to be useful under some conditions, none of these really satisfied all the requirements under all lighting conditions.

After considerable experimentation, we came up with a program of lighting and marking for turf airports which we feel comes reasonably close to meeting the requirements stipulated here. For airport location, we came up with a unique shaped Locator---a pyramid, figure 1-19. This device provides for the positive identification of an airport. We have found that the maximum contrast of black and white is the only color combination which will provide complete recognition under all lighting conditions. The wind sock is located above the pyramid-shaped airport Locator to provide a unique location so that the wind sock is readily locatable for determination of landing direction. Also, the outriggers on the Locator can be marked with various symbols to provide appropriate runway information.

This next photograph, figure 1-20, gives you an indication of how this system looks from the air at about 1,500 feet. The outriggers being parallel to the landing area provides good circling guidance for approaching aircraft. The runway edge markers are hardly noticeable at this location; however, the next photograph, figure 1-21, shows the head-on approach to the landing area, providing good lateral guidance for final approach. The edge markers are a combination black and white panel which provides maximum contrast and adequate guidance through all ranges of visibility. The diagonally striped black and white panels provide the aiming point for touchdown guidance. Rollout guidance is adequately provided by the black and white panels every 200 feet. Threshold and runway end identification panels are provided in the appropriate colors of green and red. The next diagram, figure 1-22, indicates the basic layout of all marking and lighting for the turf airport. Night operations are provided for by appropriate lighting of the airport Locator and the placing of colored lights at the threshold and runway end based upon the standard lighting configuration. The displaced threshold is arranged as shown in this illustration, with the lights and panel color combinations directed in the appropriate directions. In addition, we are adding omnidirectional white lights at the glidepath intercept or aiming point location.

For night operations, this basic lighting provides a good definition of the landing area throughout the final approach. In addition, retroreflectors are placed on the black and white panels every 200 feet along the edge of the runway. When the light from the aircraft's landing light illuminates the retroreflectors, as shown in the next picture, figure 1-23, the whole runway seems to blossom up as if it were lighted. These retroreflectors then provide adequate illumination for appropriate guidance of the aircraft to touchdown, rollout, and exit. In addition, the taxiway markers have blue reflectors which outline the taxiway for guidance during night operations.

In order to provide vertical final approach guidance we will now discuss VASI's. On the turf runway, we experimented with the several forms of POMOLA, the Cummings Lane Light System and the standard SAVASI. This photograph, figure 1-24, shows you an indication of a standard bicolor VASI and the fluorescent orange POMOLA on the left side of the turf runway. This happened to be an earlier scene during snow coverage and gives you some indication of the difference in

contrast between the black and white panel, and the yellow cones which we found to be the better of all the other systems tested for runway edge marking. The fluorescent orange POMOLA is shown in the next photograph, figure 1-25, with the current marking system.

NAFEC has, over the last few years, done considerable testing on various types of VASI systems. We recently performed a survey of low-cost visual guidance aids, where we looked at the basic bicolor system, the tricolor system, alignment of elements, and geometric pattern type VASI's. The first question we should answer is, "Why do we need a VASI at general aviation airports?" The answer to this is essentially twofold: (1) we want to maximize the utilization of short runways by touching down as early as possible while maintaining a reasonable margin of safety, and (2) we need to have a mechanism for providing clearance over obstructions along the approach path to the runway.

The obstruction problem is serious at many of our airports having power lines, roads, and other obstructions along the ends of the runways. We at NAFEC have in past years done considerable work in attempting to find better ways to mark obstructions. This effort has not been too successful; therefore, we feel that the alternative to this is to provide a VASI system to furnish good visual approach slope guidance to the pilot in avoiding these obstructions.

Currently, the lowest-cost VASI that is approved by the FAA is the bicolor SAVASI, which costs approximately \$1,000 for acquisition, and up to \$1,300 for installation. The SAVASI will do the job effectively, and if you consider \$2,300 to be within your budget, by all means install the system at your airport. Tricolor VASI's have fallen far short of their expectations, generally have a very limited range, and have a possible danger area in the transition zone from green to red providing an erroneous amber signal. Considerable testing was performed on geometric patterns such as diamonds, elipses, and squares painted on the runway with the conclusion being that these are not adequate for approach guidance. The human eye does not sense squareness or roundness with sufficient accuracy to provide adequate vertical guidance control. The VASI systems, utilizing alignment of elements, do however, show promise. We are currently evaluating the fluorescent orange POMOLA, a black/white version and the Cumming Land Light System.

The next illustration, figure 1-26, gives you an indication of the relative response of such a system based upon theoretical considerations and tests performed in Australia and at NAFEC. This indicates that we can expect a 95-percent probability of pilot response when he can view a misalignment of elements over an angle of approximately 1°arc minute. The next illustration, figure 1-27, shows the accuracy that we can expect based upon these figures for a VASI system set at 5°. This means that, for the POMOLA being tested, with a sensitivity of 1° per foot deviation from alignment, we can expect the accuracy while flying this VASI system to be within 1° of the planned glide slope from approximately a 3/4-mile range to touchdown. For most general aviation applications we feel that this would provide adequate vertical guidance. We have also found from flight testing at NAFEC, that we can obtain vertical guidance on the POMOLA from approximately 3/4 mile to touchdown under all lighting conditions with an accuracy of almost 1 percent.

We at NAFEC have found that general aviation light aircraft pilots consistently use a higher angle of approach than the 3° recommended for VASI systems. This has also been verified by NASA who recently tracked some 1,600 targets at four uncontrolled airports in the Maryland/Virginia area. They found that the median flightpath angle ranged from 4.7° at long runways to 6.1° at short runways. We are recommending that the glidepath angle for VASI systems at general aviation airports should be set at 5°.

Part 77 of the FAR defines the obstruction clearance for hard surface runways as a 20:1 slope beginning 200 feet beyond the end of the runway. The obstruction clearance definition for turf runways has generally been interpreted as meaning a 20:1 slope beginning at the start of the landing area. We are recommending that the obstruction clearance for turf runways be defined as a 15:1 slope starting 100 feet from the threshold.

We are recommending that the glidepath intercept be located approximately 150 feet from the threshold. This logic will provide the clearance as shown in the illustration, figure 1-28, which allows for over 1° of error in flying the VASI system.

The location of typical obstructions in this clearance zone, based upon current criteria, is shown in figure 1-29. We also find that the 7:1 transitional surface requirements for defining the imaginary surfaces surrounding airports is a severe restriction for small airports. The 7:1 slope would disqualify a large number of the current turf strips and other small airports throughout the country. We are recommending that this be cut in half to a 3.5:1 transitional slope surface which will give you the obstruction clearance shown. The next illustration shows the imaginary surfaces generated by the revised criteria in figure 1-30. We are also recommending that in-service tests be conducted with the basic marking and lighting systems developed here at NAFEC on turf runways at different geographical locations throughout the country.

The next subject I want to talk about is frangible light structures. Current approach light structures present a serious hazard to aircraft that may inadvertantly make an approach too low. The next photograph, figure 1-31, demonstrates what can happen to a general aviation aircraft when unexpectantly encountering an approach light structure. This aircraft was left hanging when he made his approach a little too low at Capitol City Airport in Harrisburg, approximately a year ago. In order to avoid this type of accident, the FAA several years ago initiated a development contract with ASE to: (1) develop for the FAA a frangible light support structure to support the ALS, and (2) to perform tests to compare the performance of this pole with the frangible Belgium type SN/A pole, more commonly known in this country as the VEGA pole, and a Canadian pole. The ASE frangible pole was designed to survive a 75 mile per hour wind with 1/2 inch of ice. The results of the impact testing indicated that the ASE poles were the most frangible. ASE was given a contract to install a full ALSF II with the ASE poles on runway 31 at NAFEC, figure 1-32. This installation was almost completed in February 1976, when a high velocity wind and ice storm hit NAFEC, causing many of the larger structures to collapse. From this experience we came to the conclusion that the ASE poles were too frangible. There was some indication that this may have resulted from a design

problem fault causing creeping at the lower frangible pressure joint due to vibrations. Because of lack of funds, the full ALSF II was not reinstalled. However, NAFEC did provide a fix by installing three small shear rivets in the lower pressure joint, and reinstalled a portion of the system as an SSALSR, figure 1-33. This system can currently be seen on the approach to runway 31 at NAFEC.

In the meantime, because of the problems of over-frangibility of the ASE pole and a desire by various elements within the FAA to have a "T" pole arrangement in lieu of a single pole for each light, a new effort was generated within the FAA to develop a different type of frangible pole. The Airways Facility Service contracted for the development of fiberglass pole structures for this purpose. We anticipate the start of testing of this pole this summer or early fall.

The FAA is hopeful that it can come up with a successful frangible pole design and plans are being made to implement any future ALS installations with frangible poles. The newer MALS systems are currently installed with the VEGA-type frangible pole. Already we have experienced four instances of general aviation aircraft hitting these poles with minimum damage to the aircraft and with the aircraft continuing to a successful landing. Any new MALS installations will be with frangible poles. Any new ALSF II installations will be either the new fiberglass poles or the aluminum VEGA-type poles, depending upon the results of the testing to be performed here at NAFEC. Plans are currently underway to install ALSF II's with frangible poles at Richmond and Detroit. Planning is also underway for a multimillion dollar implementation and retrofit program pending successful testing of the frangible poles.

The next item I would like to discuss is low-cost crash-fire-rescue equipment. You have probably seen this device out front and will get a chance to see it demonstrated on the tour this Friday. This equipment is totally self-contained and can be either skid mounted or trailer mounted as shown, figure 1-34, and has a potential capability of high mobility. The fire extinguishing characteristics of mechanical foams and dry chemical powders make these agents complementary for combined use on aircraft fuel spill fires. The dry chemical powder provides rapid flame knockdown but it does not provide protection of the hot fuel surface from possible reignition. In contrast, the mechanical foam has the capability of providing an efficient fuel vapor securing blanket after fire extinguishment. Therefore, this combined agent attack has outstanding possibilities for fuel fire control and extinguishment. The characteristics, figure 1-35, of this twin agent system along with the relative economical cost, in comparison with other fire-fighting equipment, can make it a highly desireable vehicle for implementation of the crash-fire-rescue system at general aviation airports.

I would like now to discuss briefly the marking of hard surface runways at general aviation airports. We find that a large number of hard surfaced general aviation airports have no markings whatsoever. Also, there are a considerable number of airports that have nonstandard markings or paint color schemes that are not considered standard. In the last several years, there have been a number of recommendations for other paint schemes or other colors for various purposes. We have performed tests of these schemes here at NAFEC,

including lime green paint on runways, and have found that none of them are as good as the current standard black and white. We have found, even under conditions of snow coverage, that the basic white paint shows up better than the lime green.

We are recommending that any attempts to provide other types of paint marking schemes be abandoned and that the basic FAA standards as shown in Advisory Circular 150/5340-ID be followed. We recommend that the basic marking for a nonprecision instrument approach as indicated in the illustration, figure 1-36, be implemented. We are also considering a recommendation that runway edge stripes and an aiming point marking be painted on all hard surface runways; the location being dependent upon the obstruction clearance required for the runway and the VASI glidepath intercept point.

My last item today is relative to the Automatic Landing Direction Indicator (ALDI). The ALDI was installed at the Manassas Airport several years ago for testing. The ALDI is a device which will give a visual indication to the pilot of the active runway in use and the direction of approach and landing. This device, figure 1-37, was tied to windspeed and direction sensors which provide an indication of the most desirable landing direction. The system as installed, however, had some basic problems, and under certain wind conditions would fluctuate back and forth between two different runways. This caused confusion to the pilots and created a safety hazard. Because of this, the system was removed and testing terminated.

Recently, there has been a renewed interest in an ALDI type device for airports which do not have a control tower. It is conceivable that such a system could work if the proper algorithm were developed. Several other systems have recently been tried at various airports throughout the country, with the various developers claiming that their system will work. A brief look was taken by us last year at a system at the Sussex County Airport. Their display system was a series of sequenced flashing lights alongside the runway.

Because of renewed interests in an ALDI type system, NAFEC will be refurbishing the system that was installed at Manassas and will implement a different algorithm to determine if the basic concept is workable.

We would appreciate any comments from the general aviation industry relative to any aspects of the presentation.

FIGURE 1-17

TURF AIRPORTS

FUNCTIONAL REQUIREMENTS

AIRPORT LOCATION

AIRPORT IDENTIFICATION

RUNWAY SELECTION FOR LANDING

CIRCLING GUIDANCE

FINAL APPROACH GUIDANCE

TOUCHDOWN AND ROLLOUT GUIDANCE

EXIT IDENTIFICATION

TAXIING GUIDANCE

FIGURE 1-18

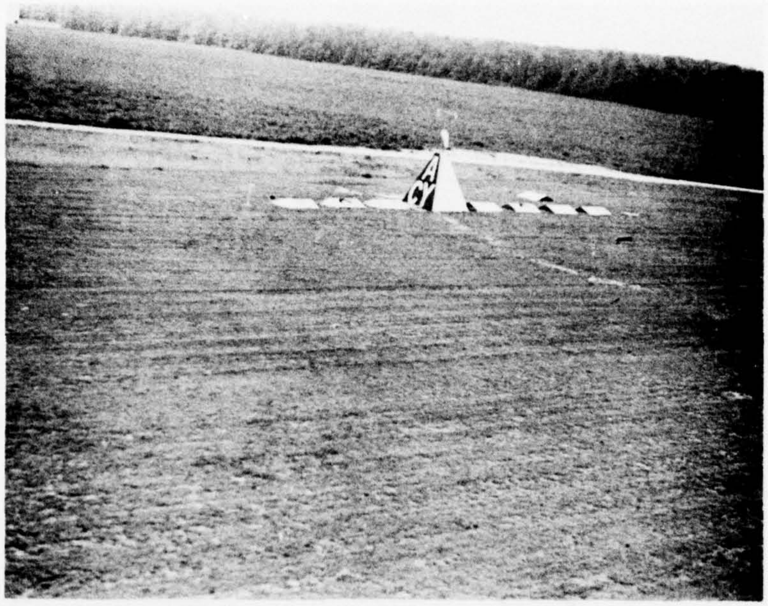


FIGURE 1-19

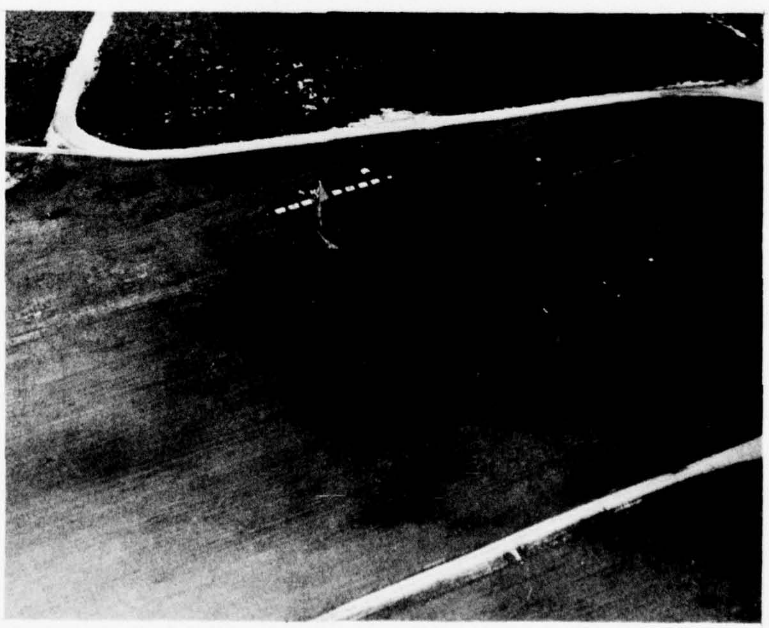


FIGURE 1-20

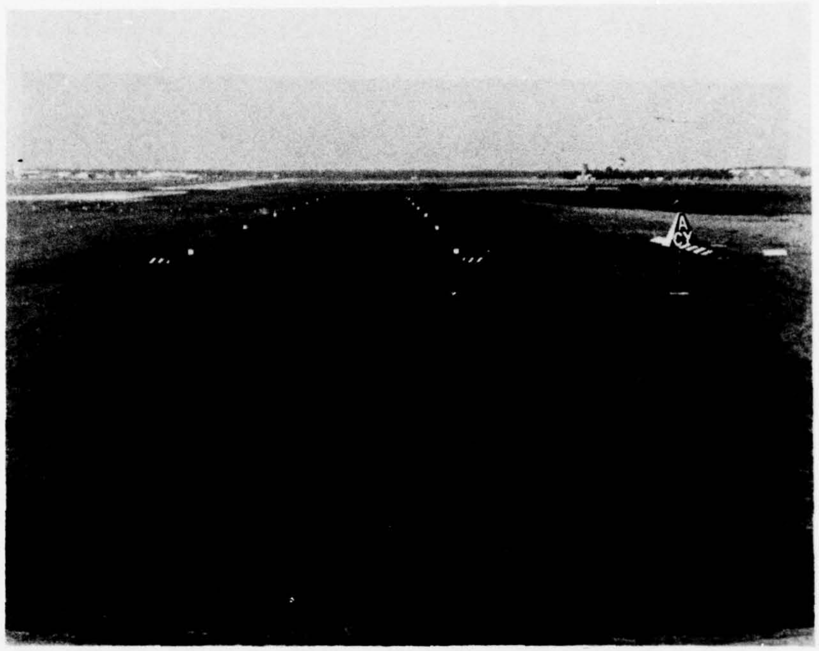


FIGURE 1-21

NAFEC TURF RUNWAY 3/21

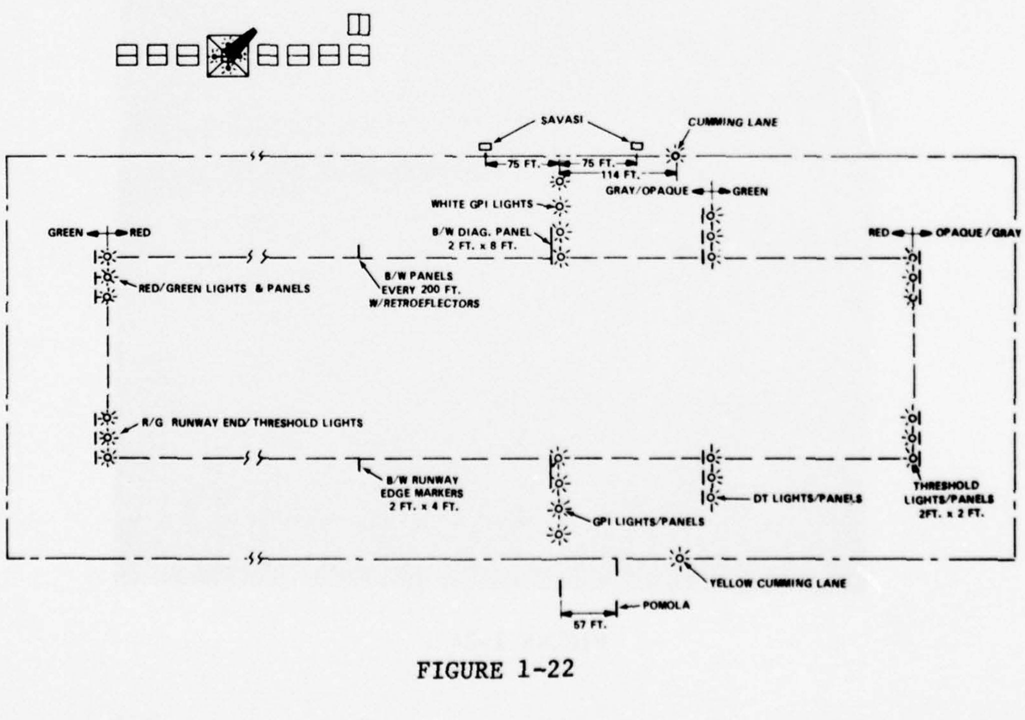


FIGURE 1-22

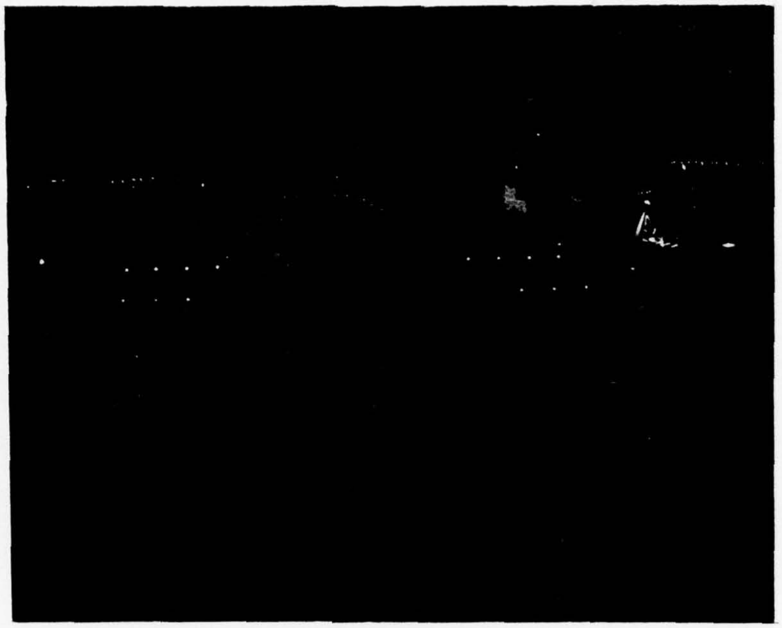


FIGURE 1-23

FIGURE 1-24

FIGURE 1-25

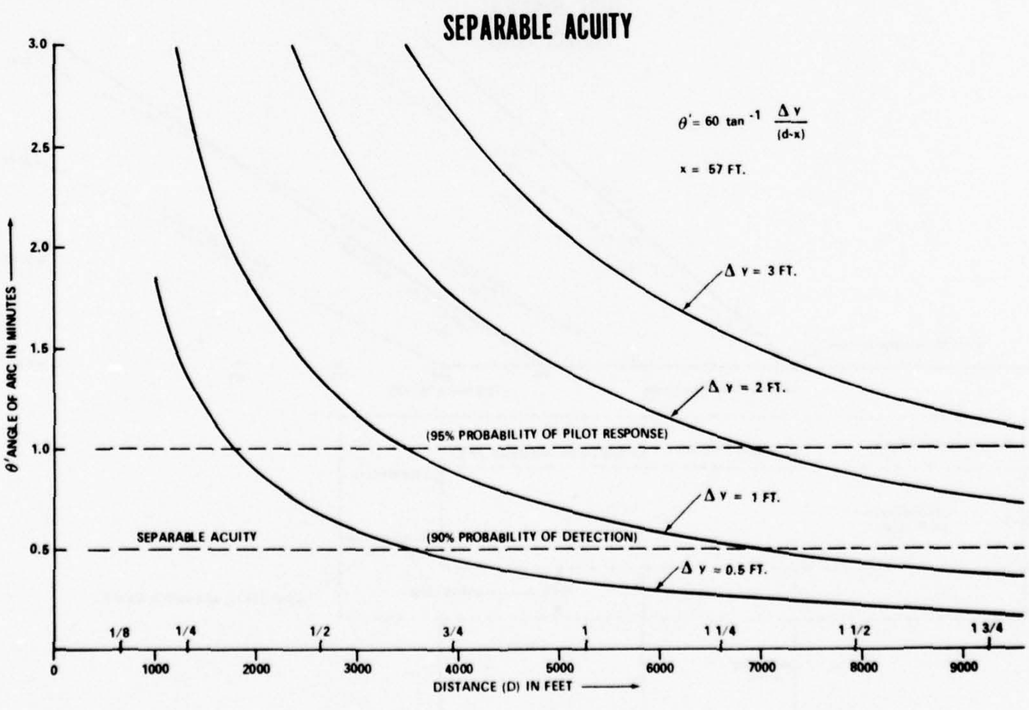


FIGURE 1-26

VERTICAL ERROR VERSUS RANGE AS FUNCTION OF SEPARABLE ACUITY

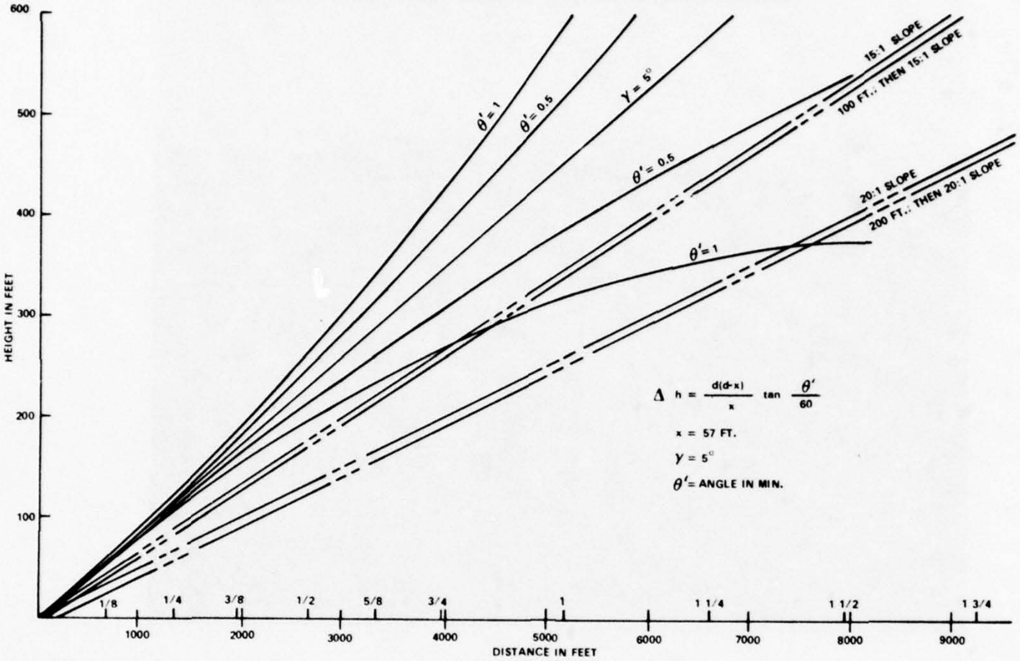


FIGURE 1-27

TURF AIRPORT
SURFACE AREAS

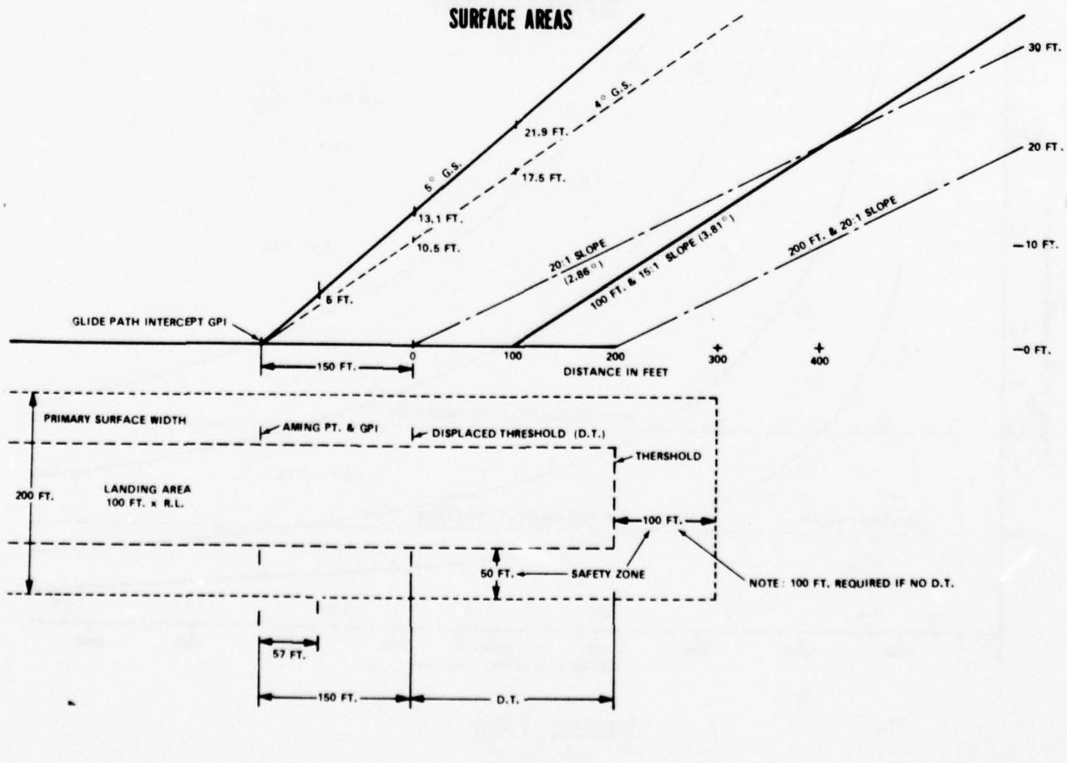


FIGURE 1-28

TURF AIRPORT
OBSTRUCTION CLEARANCE

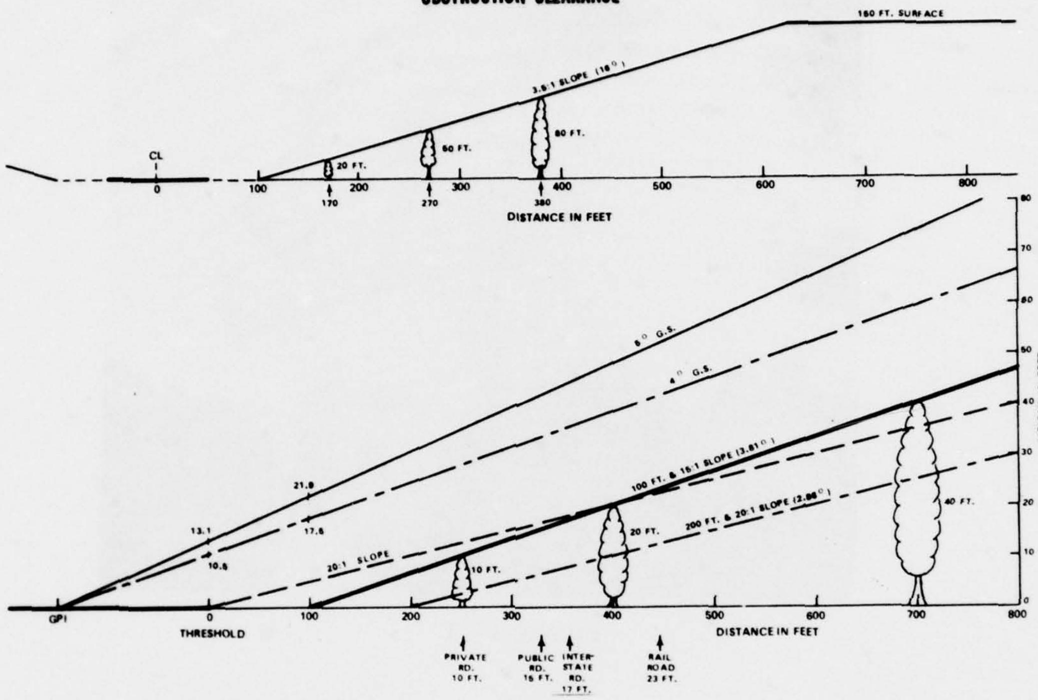


FIGURE 1-29

TURF AIRPORT
IMAGINARY SURFACES

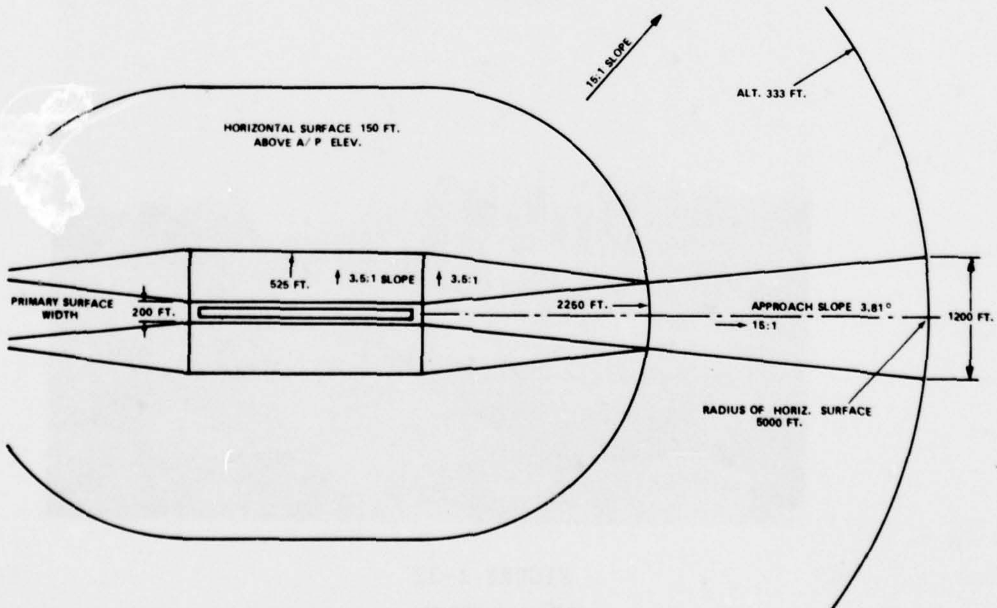


FIGURE 1-30

FIGURE 1-31

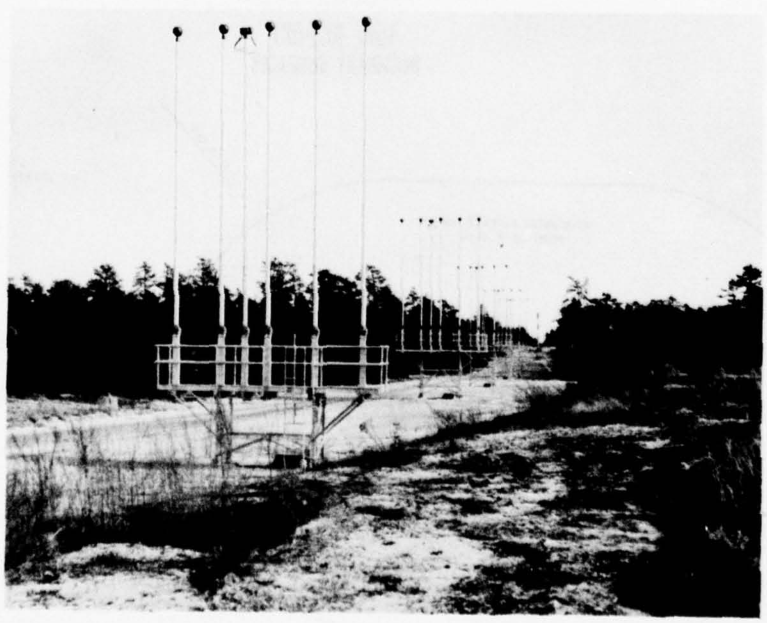


FIGURE 1-32

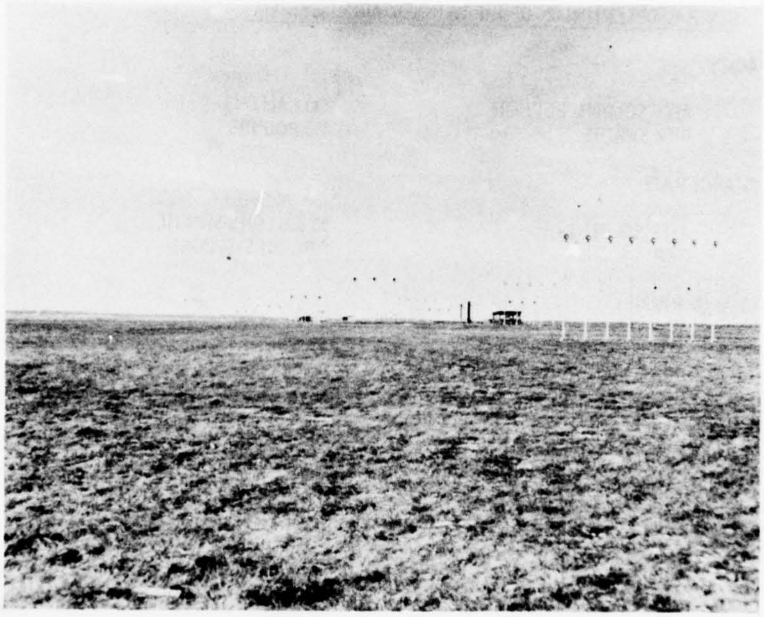


FIGURE 1-33

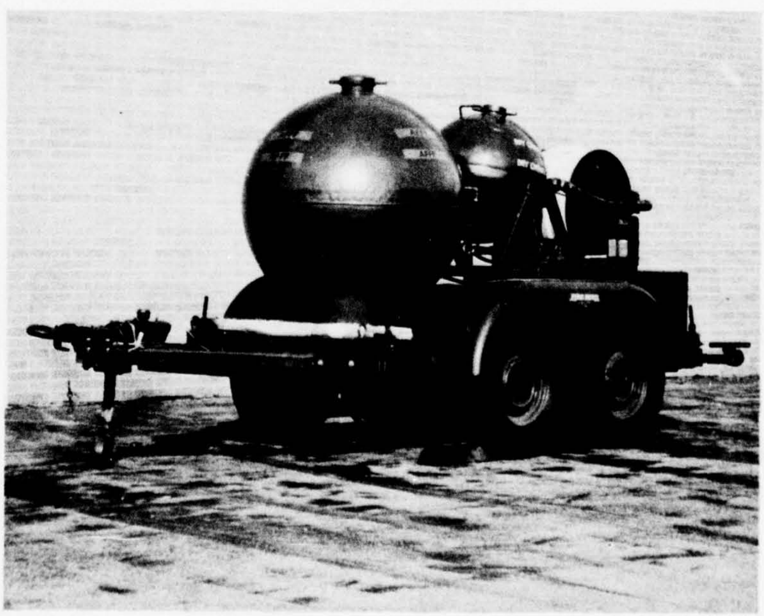


FIGURE 1-34

GENERAL DESCRIPTION OF THE TWINNED-AGENT SYSTEM

1. AGENT CAPACITY

AFFF SOLUTION SPHERE	200 GALLONS
PKP SPHERE	450 POUNDS

2. AGENT DISCHARGE RATE

AFFF SOLUTION	50 GALLONS/MINUTE
PKP	7 POUNDS/SECOND

3. AGENT DISCHARGE RANGE

AFFF	45-50 FEET LONG; 12 FEET WIDE
PKP	40-50 FEET

4. AGENT PROPULSION SYSTEM

   THREE NITROGEN CYLINDERS (DOT 3AA 2400) 300 CUBIC FEET EACH, ONE PROVIDED FOR THE PKP SPHERE TWO FOR THE AFFF CONTAINER.

5. COST

TWINNED-AGENT DISPENSING SYSTEM	$8,000
FOUR-WHEEL TRAILER	$2,000
PURPLE K POWDER	$0.45 per pound
AQUEOUS-FILM-FORMING-FOAM	$6-20 per gallon

FIGURE 1-35

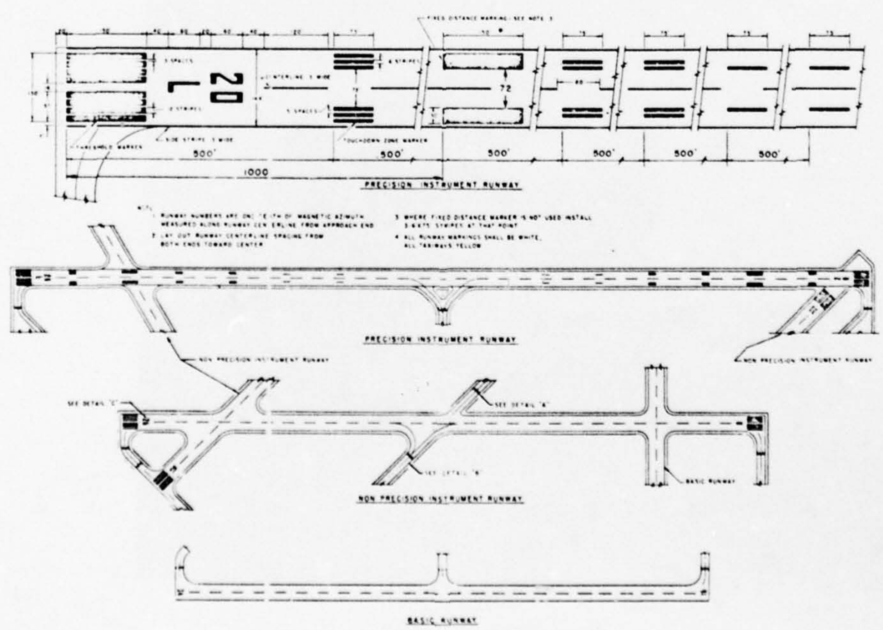


FIGURE 1. TYPICAL RUNWAY MARKING

FIGURE 1-36

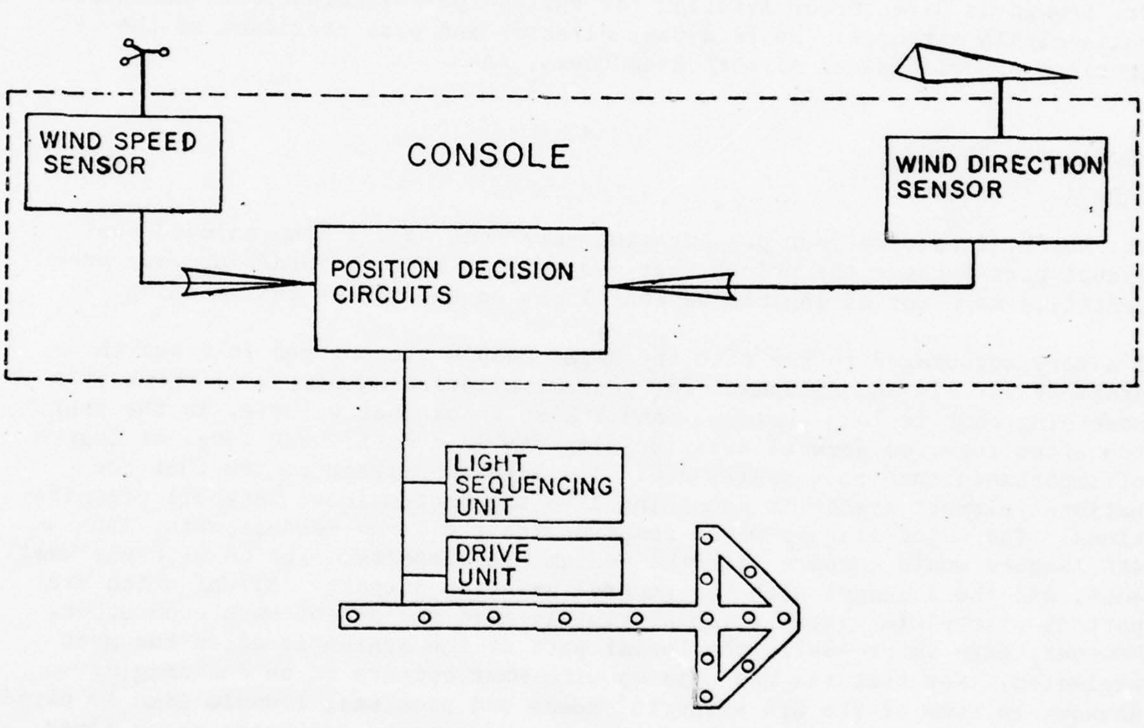

WIND SPEED SENSOR
CONSOLE
WIND DIRECTION SENSOR
POSITION DECISION CIRCUITS
LIGHT SEQUENCING UNIT
DRIVE UNIT

FIGURE 1-37

A GENERAL AVIATION USER RESPONSE TO AIRPORTS R&D PROGRAMS

MR. JOSEPH DEL BALZO

We have with us this morning, as a final speaker in the session, Mr. Austin Brough, who will present user's comments on FAA's R&D program for airports. Mr. Brough is Director of Aviation for Philadelphia International and North Philadelphia airports. He is a past director and past president of the American Association of Airport Executives, AAAE.

MR. AUSTIN BROUGH

Mr. Dosch, I enjoyed your presentation very much, and I also enjoyed the visual part because the prints that you sent me with the draft of your presentation were not as legible as what I saw on the screen this morning.

I'm very encouraged to see that the NAFEC people are engaged in research projects for aid and equipment for general aviation airports. I think it's something that is long overdue. And I also think that we have, in the past, too often regarded general aviation airports in a much lower level or degree of importance than they really are. I'd like to suggest to you that the national airport system is something like the professional baseball organizations. The major leagues would compare with the large hub airports. The AAA leagues would compare with the medium hub airports. The AA with the small hubs, and the A league with the general aviation airport. All of which are part of a complete system which absolutely need and depend upon each other. However, like in pro-ball, the lowest part of the system is often the most neglected. Now that FAA has come up with what appears to be encouraging answers to some of the G/A airports' needs and problems, I would like to direct a question to them, and ask them, how they propose to implement these ideas.

General aviation airports are generally composed of two types: publicly owned and privately owned. In the case of publicly owned, there is financial assistance available in the form of ADAP. But for the private owners, this does not exist. Under FAA's present policy, F&E will install certain navigational aides at privately owned general aviation airports. If the owners meet certain FAA criteria, and if the owner will sign agreements similar to the sponsor's assurances under the ADAP program. However, amongst those agreements, they must agree to reimburse the FAA on a prorata basis if they cease to continue as a public-use airport. The emphasis here is that a privately owned airport must meet FAA criteria for NAVAID facilities. Now, some of the items that Mr. Dosch has described are not in this category, such as the fire equipment, and most G/A's airports must either go along for 100 percent of the cost, or do without. And remember that most of the private general aviation airports, and you probably know it better than I do, pay taxes; whereas, the public ones do not.

For a moment, let's take a look at the extent of the problem. Here is New Jersey there are approximately 84 public-use general aviation airports, 70 are privately owned, only 14 are publicly owned. In my own state of Pennsylvania, there are 181 public use general aviation airports, 113 are privately owned, only 68 are publicly owned. In the two states, of a total of 265 general aviation public-use airports, only 82 are able to ask for federal assistance, while 183 are high and dry to figure it out for themselves. Like the A league baseball team, they ride in old buses, sleep in second and third rate hotels, and take cold showers.

If F&E can install NAVAIDS and get written assurances from private owners of G/A airports that meet the criteria, I ask the question: Why the same principal cannot apply using ADAP money? And, in case some of you are not aware of it, if ADAP money is used, 90 percent of the total cost is funded by the ADAP funds. That is not taxpayers' money by the way, that is money that is put into a trust fund from the users of the airlines. If FAA's answer to that question should be: That the legislation doesn't permit it. I'm here to tell you that I have never heard anyone from FAA make a pitch for this in the Congressional hearings on ADAP. I testified in some of those hearings and I have heard the FAA's presentations, and I never heard this matter introduced. I just can't accept the fact that the large percentage of general aviation airports that are a part of the national airport system, privately owned or publicly owned, should not be able to avail themselves of the opportunity of providing the most efficient and modern safe methods of getting the airplanes in and out of those airports. And I think there is a responsibility of the federal government to find a way to accomplish this. And I say in concluding, let's give them a chance to move up a little bit from the bush league of A league baseball. Thank you very much.

QUESTION AND ANSWER--SESSION I

AIRMEN SECTION

MR. DEL BALZO

We have time for questions and answers, would anyone care to open it up?

MR. RICK BARTEL (Air Taxi and Commercial Pilots Association (ATCPA) Human Factors Engineer) - Question

I have a question for Mr. Riddle. The FAA has in previous years put a lot of emphasis on the statement that knowledge is safety. And we now are putting emphasis on the statement that we are going to train to a standard. Rumor has it that someone in the FAA is planning to do away with all of the written examinations. The question is, is this true and why?

MR. RIDDLE - Answer

The statement is true. We currently are working on a project that will be aimed at eliminating written tests. This project will come out as another proposed rule-making and all segments of industry will have the opportunity to comment on it. We felt that this might be a step we want to take. Of course, it depends on the comments we receive when the notice goes out as to whether or not this will ever be a reality. But we felt that the written test concept, as it is today, was not doing the job we expected it to do. There was the problem of security of our test materials, compromise, the question of the validity of a 24-month period, for example, from the time one takes the written test until the test results expire. And these are some of the things we will consider in the project, and as I say, no final determination has been made and nothing will be made until such time as the notice of proposed rule making goes out. At this point I couldn't even give you an estimate of when that might be.

(Unidentified Individual) - Question

For Dr. Mohler, with respect to shoulder harnesses. It seems to me to be self evident that they are good. Do you have any data on the success of the diagonal shoulder harness as opposed to what I think of as the military shoulder harness?

DR. MOHLER - Answer

Yes. The preferred shoulder harness, as a general statement, would be a harness that goes across both shoulders. Because this would, in all angles and directions give the most protection. However, a diagonal one is at least 80 percent as effective as that, and since people are more prone to use the diagonal one, we have supported the installation and use of diagonal ones. We also support the others of course.

(Same Unidentified Individual)- Comment

Question for Mr. Russell. With respect to spins, I couldn't agree more. I have always taught spins and think that it was ridiculous to abandon spin training. If we have airplanes that will spin, we have got to teach pilots what to do about it. I think it was a fool political decision. Now then, you say we have some airplanes that are not spinnable, that is not right. They are spinnable, they are just not safe. It's not the same thing at all.

MR. JAY LAVENSON (Harlan Inc., Aviation Insurance) - Question

I would like to address my question to Stan Mohler, whom I have known and respected for 10 or 15 years. I would like to ask Stan about a subject which the FAA really does not like to talk about. The subject is drinking accidents and weather accidents. There really is no such thing in my mind, and I believe in the minds of some of the people in the FAA, as a weather accident or a drinking accident. The problem is what makes a pilot ignore the weather or what makes the pilot drink. It is also the same kind of thing that makes the pilot ignore the thoroughness of a preflight examination. It is in a few words, a lack of the will to live on the part of the pilot. It is emotional and it is psychological. I know the FAA has done a considerable amount of research in this area. It has meritorious information in copious files. I would like to ask, if the FAA does not think it would be helpful to general aviation to begin to educate the average person on psychological problems, to have the general aviation pilot begin to understand what makes him do some things that he may not, after the occurence, realize he had reason to do. Would it not be helpful by informing pilots of what goes on in their history, and what goes on in their upbringing in the early parts of their lives, that sometimes prohibits their reaching maturity before they kill themselves?

DR MOHLER - Answer

Right. Mr. Lavenson is involved in the insurance business and he comes across a great deal of fatalities which really shouldn't have happened. We do think of weather accidents as deliberate, intentional penetration of adverse conditions that are beyond the ability of the pilot or the airplane. And not accidental penetrations. Most of the weather accidents are deliberate; they are brought about by the decisions that the pilot makes. The same thing is true of alcohol and emotional type accidents where the pilot buzzes someone to harass the individual and shows very poor judgment because he is letting

his emotions cause him to fly rather than his reasoning powers. What we have done in this latter respect is "psychological autopsies". After the accident, the immediate background, and perhaps even a little longer range background of the pilot are studied. It has been found that some of these pilots have had problems piling up on them. For example, the Internal Revenue Service beginning to close in, or the pilot has domestic problems, or there has been a continuing down turn in his business enterprises. Sometimes this gets to be such crushing pressure on the individual that the individual turns to his airplane for release and may in a subconscious way do something dangerous or may even commit suicide in a sense. So we are attempting to get this out, and we will have to be more aggressive in these so-called psycho-social areas in our education program, so that pilots more and more will have self-awareness of the influence of these factors on their flight, the potential influence of these factors on their safe flight.

MR. J. LAUDERBAUGH (Florida Institute of Technology) - Comment

This year we will have completed about 30,000 hours of training and we will have issued about 230 certificates. I am particularly interested in several of the comments that were made by Jim Riddle and Mr. Pat Russell and Jack Eggspuehler who I have never had the pleasure of talking with. We are both in the same business, and Jim, we applaud the use of the simulators. You mentioned that Flight Standards had authorized additional use of simulators in the approved FAR 141 program. However, this is at the sacrifice of dual instruction time. We have an awful lot of instrument simulator time authorized presently in the program today. The problem is when we substitute it on a one-per-one basis, one-per-one dual instruction, there just isn't enough of dual instruction left to give both the amount of simulator time we want to give and the amount of dual instruction that we must give. On the other hand, there seems to be an awful lot of solo time. In our opinion, it's being wasted. Perhaps in the future, you might address yourself to the question of how we will be able to use this simulator time that you have authorized. We are, all of us, operating economically and, whether we like it or not, everybody is programmed around the minimum hours for the 141 program. This is really the big reason why the simulator time cannot be taken full advantage of. The second comment I would like to make, to Mr. Pat Russell, is that I applaud some of the arguments he has used on civil pilot training improvement. And I would like to suggest that a consideration be given, as Jack Eggspuehler mentioned a few minutes ago, that the universities be given more opportunity for creativity and initiative on their own developed training programs. Now I think what we might talk about is a two-tier system where institutions which have proven that they are capable of innovation and development in training be given a little more leeway in the private flying school program and be held accountable and responsible to turn out a product. In the case of the "ma and pa" operation, where they do not have a capability or the background to be able to go out on their own, they probably might be on a more structured program. So in this matter, the institutions of learning might be able to bring a little bit more initiative into the program. I think we should go

on and parallel our thinking on this. In the universities today, we have many business courses. We give a baccalaureate degree in business. But none of the business courses are identical. There are a lot of different ways to teach flying, and there are a lot of different ways to teach pilots. And we ought to have an opportunity to explore these methods through varied structured curriculums. The third point I would like to mention, is this fascination with spins. I hesitate to think what 33 pilots in my organization are going to do. These are young pilots who are out experimenting and want to do things. We don't do acrobatics today because of the consequences. If we go out and start doing acrobatics, the next thing you know, every airplane will be out doing acrobatics. They will be unauthorized; we'll have broken instruments, broken airplanes, and broken pilots. And I think in spin recovery, we've got much the same thing to think about; what are the consequences of involving people in spin recovery. I might suggest an alternative approach, and that is let's teach spin avoidance. Let's teach people how to avoid spins, a parallel again. We don't take sea captains and sink their ships in an attempt to teach them how to recover their ship. And we don't take doctors of medicine and put them at an operating table and let a person start to die and say, okay save them. We're teaching preventive medicine, we're teaching people how to prevent things from happening. In this regard, I suggest that we could go a long way in teaching people how to prevent spins from happening, how to prevent them from stalling, how to prevent them from making bad landings through a good innovative educational system. Thank you very much.

MR. GARY KITELY (Auburn University School of Aviation) - Comment

I agree with the programs presented by the panel and the comments that Jack made regarding the approach to teaching judgment. I have one other question or suggestion, I don't know which. Relative to the pilot and training improvement program that Pat Russell discussed, I look on the pilot educational process as a 3-corner loop involving the pilot himself or the trainee, the training method, and the third, which we haven't really touched on is, the flight instructor or the teacher. I would either ask or suggest that in any program that addresses pilot training improvement, we pay particular attention to the teacher, the teaching process, and how we can upgrade the teachers themselves, if they need upgrading.

MR. DEL BALZO

It's clear that there are many other questions. There are a lot of other hands that were up that we didn't get around to. I would ask those of you who didn't get a chance to be heard, to jot your question down on a card or a piece of paper give them to myself or to Larry Langweil or to anyone that is at the registration table and we will make a point of being sure that the right person addresses the question, and we will send you a reply in writing.

MR. JAMES PYLE (Former Deputy Administrator, FAA - NPA) - Question

Just a couple of quick ones. One, Vic, I assume the ground plane obstruction criteria would not apply in the case of IFR approaches for those turf runways that have IFR approaches. And there are quite a few.

MR. VICTOR DOSCH - Answer
That is correct, I am talking primarily about VFR operations. Of course, a lot of these small airports, for IFR operations, usually have nonprecision approaches, and it is conceivable that the new criteria would be satisfactory for noninstrument approachs. That could possibly change with time.

MR. JAMES PYLE - Question (continued)

The second question which I think is terriby important for the whole question of general aviation airports, is the matter of the cost of the airport, because of certain FAA standards. I go back to Norm Crabtree's program in Ohio which I think is one of the greatest ones in the country. And he always told me, I think with a certain amount of glee, that this was built, not according to FAA standards because they were too expensive. Is anything being done about this one? Because if we can get, not a DC-3 standard, but a hard surface runway that is adequate for light twins, then I think we are way ahead of the game.

MR. VICTOR DOSCH - Answer

Here we are talking primarily about turf runways, nonpaved runways. The concept behind this is to make it as simple as possible. If you noticed the panels are usually cut into 2 foot by 4 foot plywood panels. On the POMOLA (poor man's optical landing aid), for example, the sheets are 2 foot by 8 foot. You take 2 sheets of plywood, cut them in half, and you have one spare. So the idea is to keep it as simple as possible so that the airport operator and owner can build these devices themselves with plywood, paint, and simple materials at a relatively low cost.

MR. JAMES PYLE - Comment

Vic, I am talking about the construction standards. I think these are too sophisticated, too expensive, but let me not take too much time here. I will discuss this with you afterwards.

MR. JAMES PYLE - Question

Next point, Austin, I agree with you on the ADAP thing but the sad fact is that many of the public use, privately-owned airports are disappearing because of this problem, and this is a tragedy. We all know how many privately owned, public use airports are going out of the inventory.

MR. AUSTIN BROUGH - Answer

I agree with you completely Jim and that is one of the reasons I made the observation that they also have to pay taxes on these privately owned airports. I think that there is and should be a concerted effort made on the part of the governments of the various states and the local townships in which these airports are located to find some way that at least the public use portions of those airports ought to be exempt from taxation. As long as somebody comes along and offers a little more money for a housing project, there will always be the kind of problem that exists right now at Bader Field, where there has been some agitation to try to close down Bader Field for commerical construction. The temptation is going to be there for the poor private owner who is beating his brains out trying to stay in business. Somebody dangles that money in front of him and sooner or later he is going to yield.

MR. BOB CRAWSHAW (Cessna Aircraft Company) - Question

The work on the turf runway primarily is, as you said, for single-engine airplanes. This seems commendable. The question is, are you considering, before these are released, that unless specific restrictions are placed on such a field that it will also be available for any of the heavy twins, turbo props, and those Part 25 turbofan aircraft that are certified for 3/4 of a mile field lengths and turf runway operations?

MR. VICTOR DOSCH - Answer

Certainly these items will be considered. If we establish these types of criteria, we are talking in terms of the bulk of General Aviation which is indeed the single engine aircraft and the light twins. We keep talking about large airplanes, including twin jets that will come into turf airfields. Perhaps we should consider a criteria on the airplane for going into these types of fields, i.e., can it make a 5° approach and can it land within certain restrictions such as certain landing distances? Certainly these will be considered before it becomes an advisory circular.

(Unidentified Individual) - Comment

I would like to add a comment to Austin Brough's statement of financial support for privately owned airports. I think the problem is even more deeply rooted than a lot of us realize. A couple weeks ago in the state of Nebraska, the public utilities commissioner of that state was overturned in court, in that, the Civil Aeronautics Board has jurisdiction over an intrastate commuter airline operating in that state. I think that if the Civil Aeronautics Board, which has historically had economic jurisdiction in aviation, although not as much in General Aviation as in carriers, and the FAA put their economic heads together, they could find a way to draft and implement legislation to help private airports. It is absolutely vital. We're in an industry where the general aviation operator makes an investment in ground, he makes an investment in real property, he makes an investment in aircraft, and he hasn't even opened the doors. It is a horrendous problem and privately owned airports will, in fact, disappear unless the government, some federal sources, can agressively contribute some support to this problem.

SESSION SUMMARY

MR. JOSEPH DEL BALZO

It has happened to us again. Time has just gotten away from us. And again I would ask those of you who have not had a chance to get your questions answered, jot them down on a piece of paper, and we will be sure to get back to you in writing. Before we close, I would like to try my hand at summarizing what I think I heard this morning. It seems to me we said earlier that everyone is in agreement on the need to make flight training more uniform, more consistent, simpler, and more economical. Some of the things that FAA was asked to consider this morning were the use of flight simulators in biannual flight reviews, the inclusion of weather hazards in judgmental training, and doing away with hourly flight requirements for pilot certification in favor of a performance requirement. I did not sense any consensus on the value of spin training, and I can only conclude that, although it is a subject that has been studied in depth, it still needs a little bit more work.

Other things that FAA was asked to consider were to include more emphasis on instrument capability for general aviation pilots, the upgrading of professional flight instructors, and the development of a pilot training syllabus.

In the medical research area, again we seem to be in agreement on FAA's medical research program. Some things that FAA was asked to think about included work on defining physical age rather than calendar age--particularly if serious thought is ever given to placing age limitations on general aviation pilots.

In the airports area, again I sense general agreement on FAA's R&D program. But, I think, we never really faced up to the tough question that was asked by Mr. Brough. The R&D program may be very nice, but how is it that airport operators can't take advantage of the results. The issues that we talked about include ADAP funding, taxation, the financial condition of the airport operators, and the responsibility of the federal government. They are areas that FAA needs to consider very seriously.

That's my view of how this morning went, hopefully it agrees with yours. A personal observation: when we set up the General Aviation Conference, we did it with mixed emotions. We weren't really sure of the kind of reception or participation we would get from the users that attended. If this mornings' session is any indication of how the rest of the conference will go, then I think we can be pleased. I think we have shown this morning that we can talk about a General Aviation R&D program objectively and nonemotionally. Hopefully, that will continue with the rest of the conference. Thank you for your interest and your active participation.

SESSION II

AIRCRAFT

Mr. Richard P. Skully, Director
AFS–1, Flight Standards Service

CHAIRMAN

Mr. Joseph R. Chambers
Head of Dynamic Stability Branch
Subsonic-Transonic Aerodynamics
Division, NASA/Langley

Mr. Charles R. Foster, Director
Office of Flight Environmental
Quality

Mr. William T. Westfield, Manager
Aircraft Propulsion System,
Air Pollution Program
FAA Systems Research and
Development Service

Mr. Richard W. Nelson
Airframe Branch,
Engineering and Manufacturing
Division of FAA Flight
Standards Service

Mr. Richard A. Kirsch, Chief
Aircraft Design and Criteria Branch,
Aircraft Safety and Noise Abatement
Division in Research and Development
Service, FAA Systems Research and
Develcpment Service

Mr. Stanley J. Green
Vice President and General Counsel
General Aviation Manufacturing
Association

AIRCRAFT SESSION INTRODUCTION

MR. RICHARD P. SKULLY

I would like to welcome each of you to the second session of the conference, the Aircraft Session. This afternoon we will be discussing the FAA and NASA programs relating to research and development in the aircraft area. The NASA presentation will detail the work being accomplished to increase crash survival by improving cabin or cockpit safety. The FAA's efforts in developing emission standards for General Aviation will be discussed by the Director of Environmental Quality. We will hear a discussion of the testing that has been accomplished to date on piston engine emissions, as well as attempts to further reduce the emissions and the resultant implications.

We will complete the government portion of the second session with two related presentations on improving survivability in general aviation aircraft. The first topic will describe, in general, the work being accomplished to increase crash survival by improving cabin safety. The second of this two-part presentation will detail the efforts and testing in airframe structural improvements, restraint system design, and finally impact-resistant fuel systems. You should be aware of a related demonstration in this area which will be conducted by NAFEC on Friday to evaluate impact-resistant fuel cells on the NAFEC catapult. Our final presentation this afternoon will be given by Mr. Stan Green of GAMA, who will give us a general aviation community view on our Aircraft R&D programs.

NASA's STALL/SPIN PROGRAM FOR LIGHT
GENERAL AVIATION AIRCRAFT

MR. JOSEPH R. CHAMBERS

In the few brief moments available to us this afternoon, I would like to give an overview of the background, scope, and activities of our stall/spin program for light general aviation airplanes, figure 2-1. As all of you can appreciate, this is a complex, ongoing problem area which NASA has worked for the military for many years. Our resources have necessarily been directed toward high-priority military airplanes, and since the problem is so configuration dependent, our research has not been applicable to light planes. We have recently greatly expanded our interest and research in light airplanes and now have a major program in this area, figure 2-2.

As shown in the figure 2-3, the scope of work covers a large matrix of testing techniques and capabilities. For example, Langley operates the only spin tunnel in the U.S.

Figure 2-4 lists the objectives of our research program. I would now like to expand each objective in terms of the activities and results we are obtaining in our work.

In the area of aerodynamic studies, figure 2-5, the types of activity include exploratory wind tunnel tests of a low-wing design and looking at aerodynamic control limiting, figure 2-6. This work is being done for us at Texas A&M by Howard Chevalier who has previously done some work for the FAA to develop a lower surface spoiler on the elevator to limit the angle of attack of the airplane.

Reference figure 2-7 we have also had some work done by Mississippi State in which we are using simulation to look at variable control stops to limit the maximum angle of attack obtainable, figure 2-8. Our plans include continuing evaluation of both the airframe approach and the control system approach using wind tunnel, simulation, and in-flight approaches. We are involved in flight tests down at Mississippi State, with in-flight evaluation of variable control stops for angle of attack limiting. And one last point, I mentioned the advanced concepts. We are quite eager to look at what you might do if you took a new look at general aviation aircraft and maybe put the tail out front or made it look a little different, the possibility of possibly inherently stall proofing the airplane. We do plan some wind tunnel tests in the full-scale tunnel of Bert Rutan's VariEze airplane, probably around next March.

One area that we have started on in recent years is in the area of the fully developed spin and spin recovery. That work has progressed well, and the first configuration that we have taken a look at is the low-wing airplane, figure 2-9. The work itself involves spin tunnel tests, radio control model tests, and the full-scale airplane flight tests. The emphasis is in trying to correlate all these results so that we can better appreciate what affects the spin recovery

of this class of aircraft, figure 2-10. The work being done in the spin tunnel makes you appreciate the matrix of the problem--these are just a few of the configuration variables that have to be looked at when you start talking about fully developed spin and how these factors affect the airplane. What we are trying to avoid by making this matrix fairly large is rather general statements that may come back to bite us. I have one example of someone making a generalization about stall/spin. This is from the hallowed halls of NACA from a technical report where a gentleman was looking at spin characteristics, and made the statement: "The following statement relative to the airplane in free flight may now be made with reasonable assurance: an airplane with a monoplane wing is not capable of flat spinning." We are trying to avoid that type of generalization that will come back to bite us in the rear.

One activity in this fully developed spin area has been to take a look at the effect of tail configuration on spin and on spin recovery. As you are probably aware, one of the design guidelines available to the industry today involves some rather simplistic guidelines that were evolved during World War II, in which the tail configuration was a primary factor to be given attention during design. There were some charts made using geometric characteristics of the tail which the designer supposedly could use to predict the spin characteristics of the airplane. There has been quite a great deal of controversy as to whether those are sufficient, particularly from the industry experience. We have done some tests at Langley to evaluate those guidelines, figure 2-11. This shows a radio control model which was flown with several tail configuration.

And in our tests, to give you the bottom line, we found that indeed, there are many, many, other things that effect the spin so extensively as to make those old design guidelines out of date. As an example, in our spin tunnel test, on this low-wing design, figure 2-12, we found that the configuration of this trailing edge fillet had vast influence on the spin characteristics. For example, when the trailing edge fillet was round, we got only steep spins and good recoveries. When we sharpened that trailing edge fillet or removed it, we got both the original steep spin, but with a tendency toward flat spins, which of course were nonrecoverable. It just gives you an idea of all the configuration variables that are very, very sensitive in this particular problem.

Our results from the model test are now beginning to be verified or at least correlated with full-scale flight test experience. We are presently in the status of flying this airplane, figure 2-13, at our Wallops Flight Station and have begun to get some results. Figure 2-14 gives you an idea of some of the correlations that we have obtained between our model test and the airplane. This shows two tail configurations, tail 6 and tail 2, which involve moving the horizontal tail around on the airplane. Results from the spin tunnel, the radio control model, and the full-scale indicate the angle of attack of the spin, the spin rate, and the number of turns for recovery from the spin. The little box to the left indicates the control positions. In this case we are talking about stick full aft, rudder full with the spin initially (right spin in this case), and then using rudder reversal for spin recovery. You can see, first of all that we are getting good correlation in terms of the developed spin characteristics, 55° angle of attack in the spin tunnel, 55° on the airplane, the spin

rate is about the same. Of tremendous concern to us, though, is the fact that recoveries are significantly different between our model test and the airplane, and we are in the process now of scratching our head trying to resolve just what the problem is.

Figure 2-15 shows what our activities in this area look like. We, of course, have done our spin tunnel test for that low wing design, we have done our model testing and now in-flight test. We are in the process of publishing a report which you might look for. It is the first in a series of reports dealing with developed spin characteristics for the low-wing model. It does have a title and report number; we expect it out on the newstand probably within the next month. We do plan to conduct investigations similar to what I just mentioned for a high-wing airplane. The baseline will be a Cessna 172, and for a twin-engine design, which we have not defined yet, we are also doing some exploratory work to evaluate the effect of leading edge spoilers on spins, figure 2-16. These are upper surface spoilers up near the leading edge, which we are finding in the spin tunnel have very large beneficial effects on the developed spin and recovery, and it looks very interesting from our point of view.

I want to talk a little bit about emergency spin recovery devices, figure 2-17. This is always a sore spot with the manufacturers in trying to define what the geometry of that parachute system should be and the mechanics of making it work. Our activity includes spin tunnel tests, where we are trying to define the canopy size required and also the dimensions of the tow line. The problem here is that if that tow line is too short the parachute will fall back into the dead air above the airplane in a spin. If it is too long, the chute will simply drift over onto the spin area of the airplane and will continue to spin merrily along with the airplane. We are going to go out and survey industry and try to collate information regarding their experiences with the total spin recovery systems in a single cookbook report on how to do it for the manufacturer.

We are also taking a look at other systems for emergency spin recovery, such as rocket systems, figure 2-18. This particular flight test not only has an advantage of being able to evaluate rockets for spin recovery, but it gives us the capability of putting in a known control input about the various control axes to evaluate relative effectiveness for spin recovery.

Our activities have included a definition of the parachute requirements for the low-wing design; that report should be out within a few months; it is now going through our editorial process. We have designed and evaluated flight hardware for our low-wing airplane which is undergoing flight test down at Wallops. We have already accomplished our checkout flights of the rocket recovery system, and the airplane is now being modified to have a chute put on for comparison purposes. Our plans include continuing studies of the chute system requirements for the high-wing and the twin engine designs, conducting that industry survey that I mentioned earlier, and conducting spin tests with the rocket recovery system. We expect these tests to be conducted probably around November.

I mentioned testing techniques earlier. One of our efforts in life is to develop a relatively inexpensive testing technique that perhaps the manufacturers could use to get some information to predict their spin characteristics before they

actually go into flight test. This looks like the Sunday afternoon type of radio control model, figure 2-19, but if you properly scale one of these models to make it produce motions representative of an airplane, they end up with fairly high wing loadings compared to your Sunday afternoon flyer, and they are fairly hot to fly. It does take a great deal of expertise and background to be able to get information from them. We are determining test procedures that they could use, particularly those that might identify dangerous spin modes.

We are trying to help them develop low-cost instrumentation to get quantitative data from their flight tests, and we are trying of course to correlate results of this testing technique with full-scale airplane results. Now the industry has picked up the technique, and as shown in the middle picture, Beech has been doing T-34 radio control model tests under NASA contract. The industry has developed the expertise of being able to fly these models, and as I mentioned, they are quite difficult to fly. The people have become so proficient that sometimes I wish they would come to Langley and help us because we have our problems in trying to fly these models, figure 2-20.

Our activities included correlating our radio control model and our spin tunnel results, figure 2-21. One obvious application of this radio control model is to look at the spin recovery characteristics of the airplane after a certain number of turns following the stall. For example, here we have shown results obtained with the radio control model following one turn, three turns, and six turns, and correlated with the spin tunnel model which of course is in a fully developed spin. You can see the angle of attack, spin rate, and turns for recovery for various control inputs. And the point I would like to make here is that obviously the airplane is not in a fully developed spin after one turn. You can see that the angle of attack continues to increase up to the spin tunnel level. The number of turns required for recovery with various control procedures obviously degrades as you get deeper into the fully developed spin.

Our activities using radio control testing techniques include completion of tests of the low-wing design, and we are waiting for correlation with the airplane, figure 2-22. We have awarded a contract to Beech for follow-on testing of the T-34C. We do plan to conduct tests of the high-wing 172 type configuration, and we do plan radio control model test of the twin-engine design.

One last point of this program---one of our, I think, good attributes, from a national point-of-view, has been NASA serving as a sort of central point of information on stall-spin characteristics for military aircraft, and I think we have served the U.S. fairly well in that capacity. I would hope that somehow NASA could kind of serve as a sounding board and help spread the word with regard to this R&D activity in stall-spin for General Aviation. We, of course, provide consultation to the industry, and we are more than happy to provide it to other agencies, figure 2-23. We do and have been involved with joint programs, both with the industry and universities, in problem areas that we feel are of national importance. For example, when Mr. Bede put a GAW airfoil on his airplane and had a spin problem; we conducted spin tunnel tests with his consent to evaluate the effects of the new airfoil.

In addition, there is very little information currently available about spin characteristics of T-tail airplanes, and we have conducted a joint program with Piper to look at spin characteristics of T-tail aircraft. That is a 20-word or less type of summary of where we stand, gentlemen. It is unfortunately very brief. I feel that Langley has been able, with your support, to formulate a very aggressive program in this area, and I think that we are going to be able to provide the industry with the type of design information they need to at least make the aircraft part of the problem a heck of a lot less than what we have today.

BACKGROUND

- OVER 70 YEARS OF ATTENTION TO STALL/SPIN
- STALL ENHANCEMENT, WARNING, AND PREVENTION CONCEPTS DEVELOPED AS EARLY AS 1920'S
- RADICALLY NEW AND INNOVATIVE CONCEPTS MAY BE REQUIRED
- EARLY RESEARCH APPLICABLE TO BOTH MILITARY AND CIVIL DESIGNS
- NACA/NASA RESEARCH DIRECTED TOWARD HIGH PRIORITY MILITARY PROJECTS DURING AND FOLLOWING WW II
- RESEARCH SINCE 1950'S GENERALLY NOT APPLICABLE TO GENERAL AVIATION DESIGNS
- STALL/SPIN WORKSHOP HELD 10/76
- RECENT EXPANSION OF PROGRAM AT LANGLEY

FIGURE 2-1

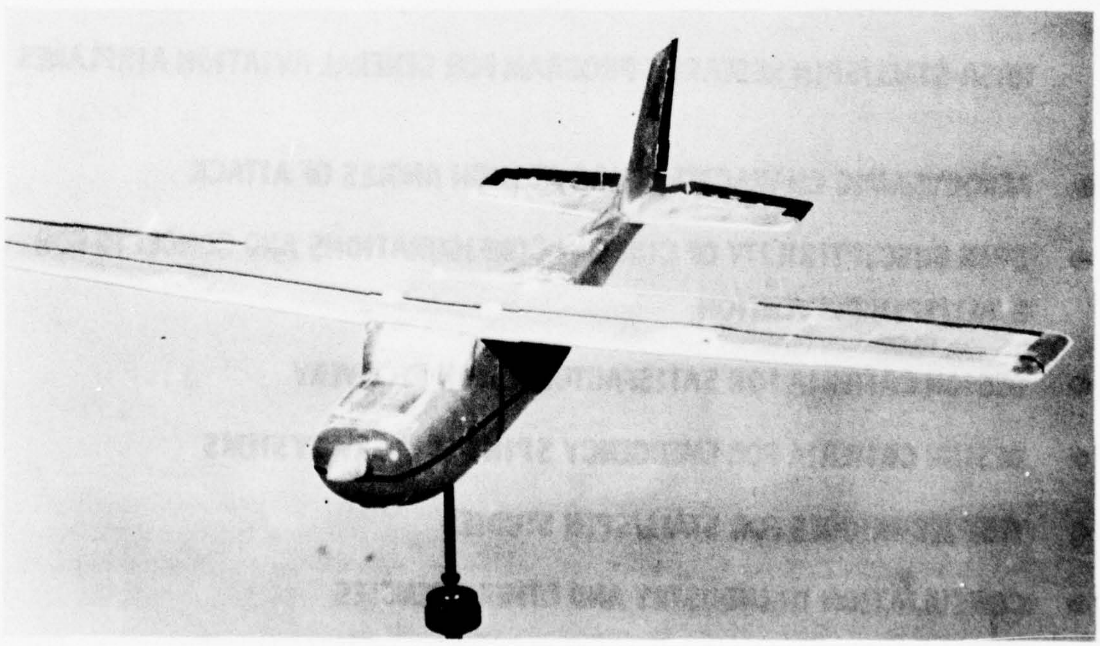
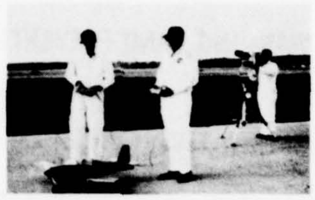
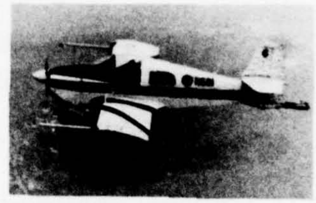


FIGURE 2-2

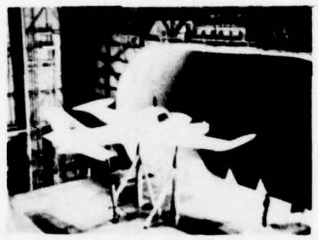
SCOPE OF STALL / SPIN RESEARCH PROGRAM


SPIN TUNNEL


RADIO-CONTROLLED MODELS


FLIGHT TESTS


WIND-TUNNEL MODELS


FULL-SCALE WIND-TUNNEL TESTS

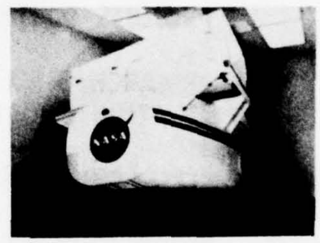

SIMULATION

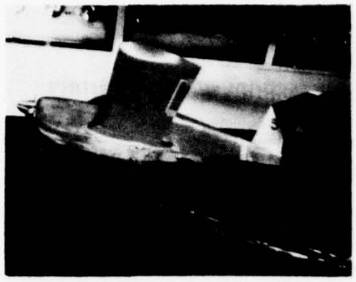
FIGURE 2-3

NASA STALL/SPIN RESEARCH PROGRAM FOR GENERAL AVIATION AIRPLANES

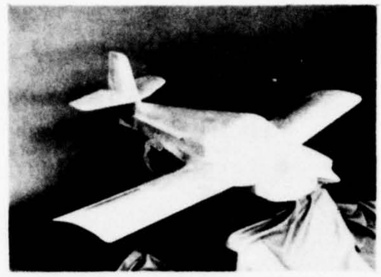
- AERODYNAMIC CHARACTERISTICS AT HIGH ANGLES OF ATTACK
- SPIN SUSCEPTIBILITY OF CURRENT CONFIGURATIONS AND CONCEPTS FOR STALL/SPIN PREVENTION
- DESIGN CRITERIA FOR SATISFACTORY SPIN RECOVERY
- DESIGN CRITERIA FOR EMERGENCY SPIN RECOVERY SYSTEMS
- TEST TECHNIQUES FOR STALL/SPIN STUDIES
- CONSULTATION TO INDUSTRY AND OTHER AGENCIES

FIGURE 2-4

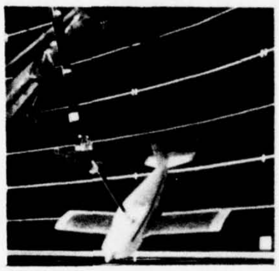
AERODYNAMIC CHARACTERISTICS



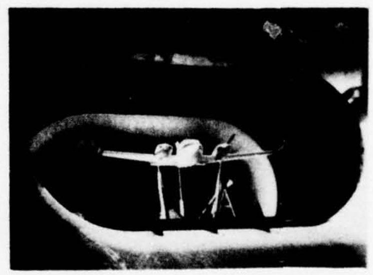
SMALL-SCALE MODEL TESTS



HIGH REYNOLDS NUMBER TESTS



ROTARY-SPIN TESTS



POWERED AIRPLANE TESTS

FIGURE 2-5

AERODYNAMIC CHARACTERISTICS

RECENT ACTIVITIES

- WIND TUNNEL MODEL TESTS FOR LARGE RANGE OF ANGLE OF ATTACK, ANGLE OF SIDESLIP, AND CONFIGURATION FEATURES
  - HIGH RN TESTS OF LOW-WING MODEL
  - LOW RN TESTS OF HIGH-WING MODEL

PLANS

- FULL-SCALE WIND TUNNEL TESTS OF POWERED AIRFRAMES
  - LOW-WING DESIGN (11/77)
  - HIGH-WING DESIGN (3/78)
  - TWIN (11/78)
- ROTARY SPIN TESTS OF LOW-WING DESIGN
  - LOW RN (8/77)
  - HIGH RN (4/78)

FIGURE 2-6

STALL SUSCEPTIBILITY AND AVOIDANCE

RECENT ACTIVITIES

- EXPLORATORY WIND-TUNNEL TESTS OF AERODYNAMIC CONTROL LIMITING (TEXAS A and M)
- SIMULATOR STUDY OF VARIABLE CONTROL STOPS (MISSISSIPPI STATE)

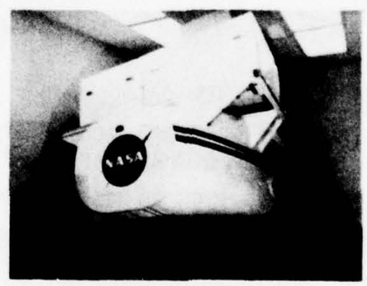
PLANS

- CONTINUING EVALUATION OF AIRFRAME AND CONTROL SYSTEM CONCEPTS
  - WIND TUNNEL
  - SIMULATION
  - FLIGHT
- WIND TUNNEL TESTS OF RUTAN VARIEZE (3/78)

FIGURE 2-7

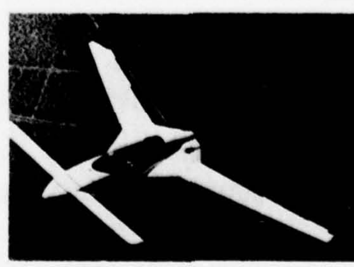
STALL SUSCEPTIBILITY AND AVOIDANCE

WIND-TUNNEL TESTS



SIMULATION

IN-FLIGHT EVALUATION



ADVANCED DESIGNS

FIGURE 2-8

DETERMINE DESIGN CRITERIA FOR SATISFACTORY SPIN RECOVERY

- EMPHASIS ON CORRELATION BETWEEN SPIN TUNNEL, RADIO-CONTROLLED MODEL, AND FLIGHT TESTS
- INCLUDES MATRIX OF CONFIGURATIONS AND TEST VARIABLES

FIGURE 2-9

SPIN TUNNEL TESTS

- DETERMINE VALIDITY OF DESIGN CRITERION AS AFFECTED BY:
  - TAIL DESIGN
  - CENTER OF GRAVITY POSITION
  - VENTRAL FINS
  - FUSELAGE SHAPE
  - AIRFOIL
  - WING PLANFORM
  - TAIL LENGTH
  - WING POSITION
  - MASS LOADING
  - CONTROL TECHNIQUE
- ADDITIONAL OUTPUTS:
  - PARACHUTE SIZE
  - MODIFICATIONS TO ELIMINATE FLAT SPINS
- TESTS ON LOW AND HIGH-WING SINGLE-ENGINE DESIGNS AND TWIN-ENGINE DESIGNS

FIGURE 2-10

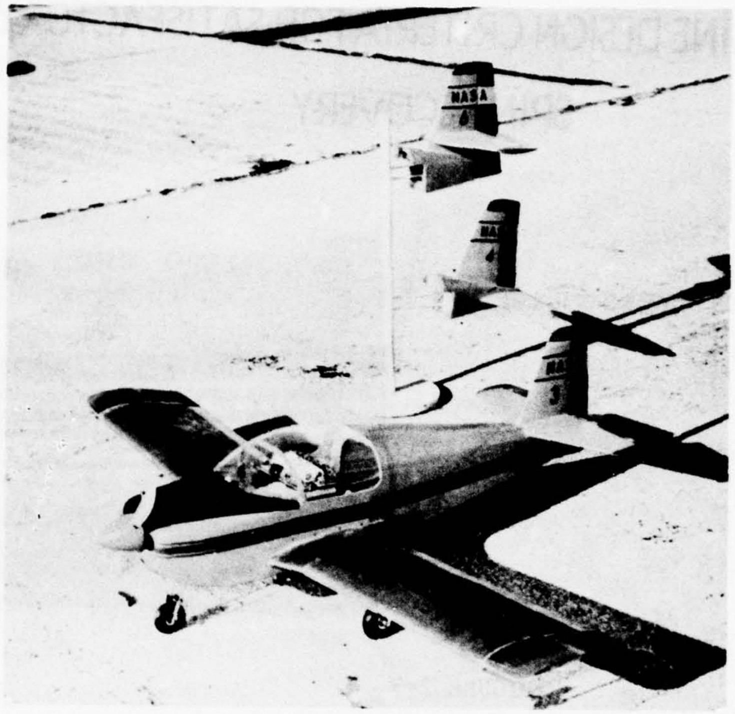


FIGURE 2-11

EFFECT OF TRAILING-EDGE FILLET ON SPIN

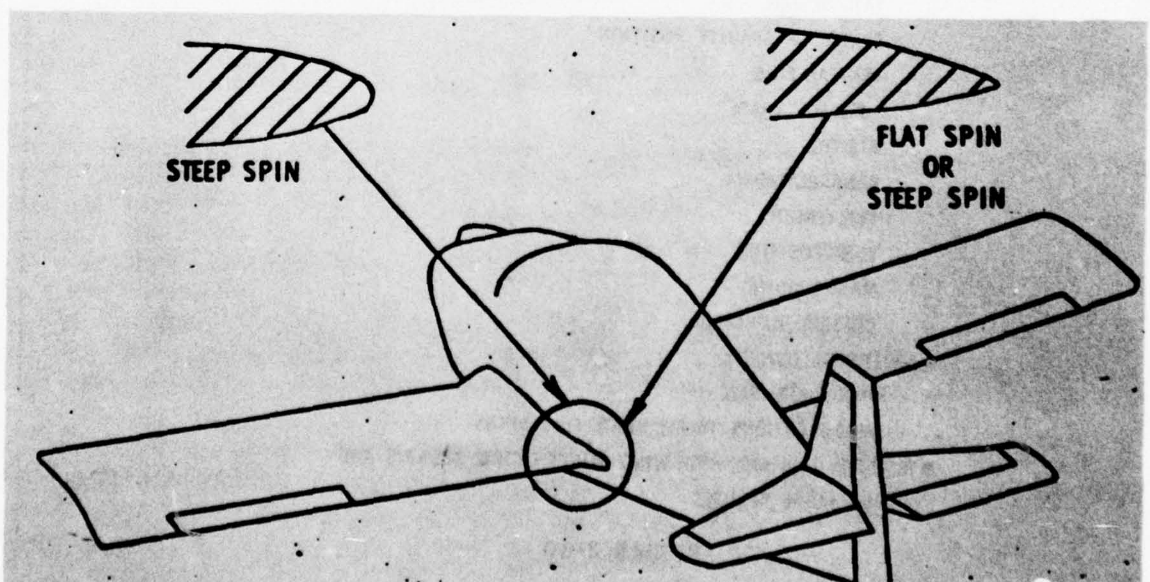


FIGURE 2-12

FIGURE 2-13

CORRELATION OF RESULTS FOR LOW-WING DESIGN

TAIL CONF	SPIN TUNNEL α, deg	SPIN TUNNEL Ω	SPIN TUNNEL Rec	RADIO CONTROL α, deg	RADIO CONTROL Ω	RADIO CONTROL Rec	FULL SCALE α, deg	FULL SCALE Ω	FULL SCALE Rec
6	55	2	$2\frac{1}{4}$	60	2	$2\frac{1}{4}$	55	2.2	$5\frac{1}{2}$
2	47	2.2	3	50	2.5	$\frac{3}{4}$	51	2.3	$6\frac{1}{4}$

FIGURE 2-14

SPIN RECOVERY

RECENT ACTIVITIES

- INVESTIGATION OF EFFECTS OF TAIL CONFIGURATION ON SPIN CHARACTERISTICS FOR LOW-WING DESIGN
  - -- SPIN TUNNEL
  - -- R/C MODEL
  - -- FLIGHT
- PUBLISH

  "SPIN TUNNEL INVESTIGATION OF THE SPINNING CHARACTERISTICS OF TYPICAL SINGLE-ENGINE GENERAL AVIATION AIRPLANE DESIGNS-I-LOW-WING MODEL A: EFFECTS OF TAIL CONFIGURATIONS" NASA TP-1009, (9/77)

PLANS

- CONDUCT SIMILAR INVESTIGATIONS FOR HIGH-WING AND TWIN-ENGINE DESIGNS
- EVALUATE EFFECT OF LEADING-EDGE SPOILERS ON SPIN

FIGURE 2-15

EFFECT OF LEADING-EDGE SPOILER ON AUTOROTATION

("Flight", Vol. 36, 1939)

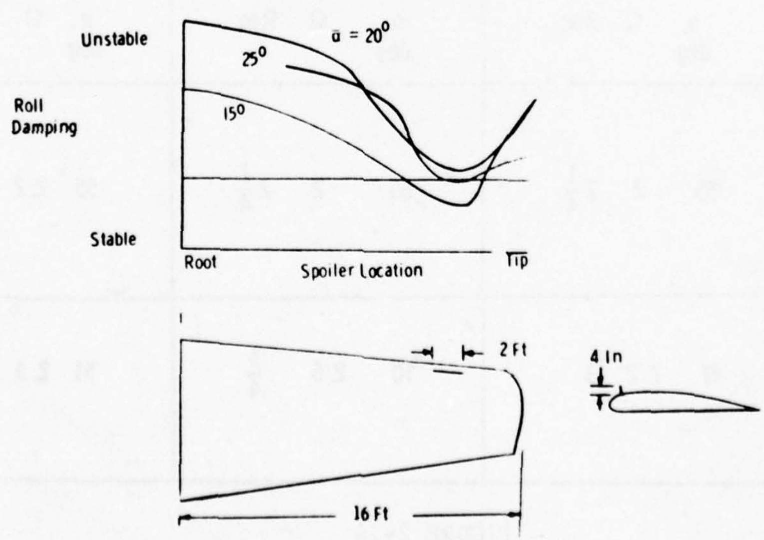
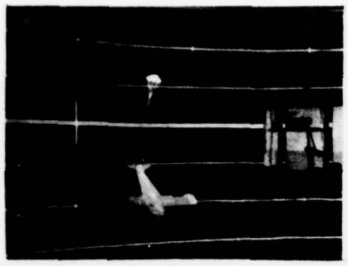
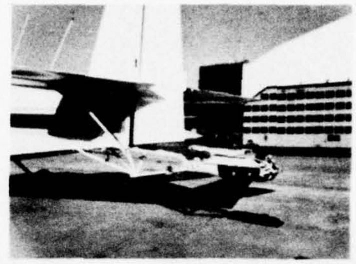


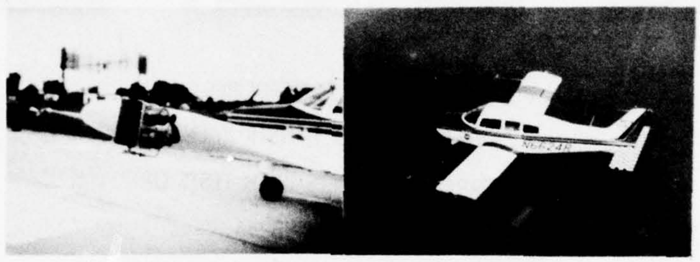
FIGURE 2-16



• DEVELOP DESIGN CRITERIA FOR GEOMETRY OF PARACHUTE SYSTEM



• SURVEY INDUSTRY AND COLLATE DATA IN SUMMARY REPORT ON SPIN RECOVERY PARACHUTE SYSTEMS



• EVALUATE USE OF ROCKETS FOR SPIN RECOVERY

FIGURE 2-17

EMERGENCY SPIN RECOVERY DEVICES

RECENT ACTIVITIES

- DEFINED PARACHUTE REQUIREMENTS FOR SATISFACTORY SPIN RECOVERY FOR LOW-WING DESIGN
- DESIGN AND EVALUATION OF FLIGHT HARDWARE FOR LOW-WING AIRPLANE
- CHECKOUT FLIGHTS OF ROCKET RECOVERY SYSTEM

PLANS

- CONTINUE STUDIES FOR HIGH-WING AND TWIN-ENGINE DESIGNS
- CONDUCT INDUSTRY SURVEY
- CONDUCT SPIN TESTS WITH ROCKET RECOVERY SYSTEM

FIGURE 2-18

RADIO-CONTROLLED MODEL TEST TECHNIQUES

- DETERMINE TEST PROCEDURES
- DEVELOP LOW-COST INSTRUMENTATION
- CORRELATE RESULTS WITH TESTS OF FULL-SCALE AIRPLANE

FIGURE 2-19

FIGURE 2-20

COMPARISON OF SPIN TUNNEL AND R/C MODEL RESULTS FOR TAIL 6

	RADIO-CONTROLLED MODEL			SPIN TUNNEL MODEL
	One turn	Three turns	Six turns	
Maximum angle of attack	32	43	52	53
Ω - seconds per turn (full scale)	-	2.4	2.1	2.1
Recovery turns Full rudder reversal	-	$\frac{1}{2}$	$1\frac{1}{2}, 1\frac{3}{4}$	$1, 1\frac{1}{4}, 1\frac{1}{2}$
Rudder and elevator neutral	$\frac{1}{4}, \frac{1}{4}, \frac{1}{4}$,	$2\frac{1}{4}, 3, 2\frac{3}{4}$	$3\frac{1}{4}, 3\frac{3}{4}$	∞

FIGURE 2-21

RADIO-CONTROLLED MODEL TEST TECHNIQUE

RECENT ACTIVITIES

- COMPLETED TESTS OF LOW-WING DESIGN
- AWARDED CONTRACT TO BEECH AIRCRAFT FOR T-34C MODEL TESTS

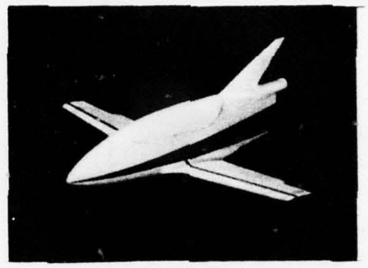
PLANS

- CONDUCT TESTS OF HIGH-WING AND TWIN-ENGINE DESIGNS

FIGURE 2-22

CONSULTATION AND JOINT PROGRAMS

- *PROVIDE CONSULTATION TO INDUSTRY AND OTHER AGENCIES*


BD-5J MODEL

- PROVIDE FOR NATIONAL COORDINATION ON PROBLEM

- CONDUCT JOINT PROGRAMS WITH INDUSTRY AND UNIVERSITIES


T-TAIL RESEARCH MODEL

FIGURE 2-23

EMISSION STANDARDS AND GENERAL AVIATION

MR. RICHARD SKULLY

Thanks very much, Joe. Our next speaker will cover emission standards as they relate to General Aviation, I am sure a very popular subject. We have Chuck Foster, who is the Director of Environmental Quality with FAA.

MR. CHARLES R. FOSTER

I would like to give you a general picture of the activities of the FAA's Office of Environmental Quality in the aircraft low-altitude emissions area. I think this will help to put the general aviation emissions work into its proper perspective.

As you know, the Environmental Protection Agency (EPA) was required to establish standards for air pollution emissions from aircraft which the EPA Administrator believed caused, or might cause, a health or welfare problem. This requirement led to the EPA's setting emission standards for General Aviation and transport category aircraft in 1973. In 1976 similar standards were established for supersonic aircraft.

The Congress directed that any standards established by EPA be implemented by FAA, and required two specific types of interagency consultation. First, none of the EPA standards are to be finalized until EPA consults with FAA regarding the time required to develop and apply the required low-emissions technology. Second, the FAA was recognized as the final authority on safety determinations. As you may realize, the Clean Air Act Amendments made a minor change in that provision, so that the EPA standards do not apply if the President disapproves them on the basis of an FAA determination of a safety problem.

Many of you may not be familiar with the kinds of work we have undertaken to ensure efficient and equitable implementation--and modification, if appropriate--of these standards. Let me take a few minutes to review a few of our projects.

Probably the most visible program we have undertaken has been the Concorde Monitoring Program at Dulles International Airport. When the Secretary of Transportation made his February 4, 1976, decision to permit limited 16-month trial periods for commercial SST service to Dulles and Kennedy airports by British Airways and Air France, he directed the FAA to monitor the noise and emissions impact at those airports. I believe that the emissions measurements we obtained from stations like this one in the past year or so are among the most valuable data of that type ever obtained, figure 2-24. In just 3 months, a network of instrumentation was set up both on and off the airport, including the nearby town of Sterling Park. Figure 2-25 shows the location of some of the instrumentation in one phase of the operation. Measurements were made at approximately three dozen locations including both portable and fixed sites. All of the data were made publicly available in a series of monthly data reports. In a few weeks we will have a detailed summary available, so I shall not go into a lot of detail now.

Dulles is a rather quiet airport, figure 2-26, located approximately 25 miles from downtown Washington, D.C., and has a very low background of pollution. As I recall, the carbon monoxide level rarely gets above one part per million--about 3 percent of the air quality standard of 35 parts per million. We had very sensitive instrumentation, otherwise we would not have been able to gather the data which showed that emissions of CO from the Concorde, and other jet airplanes, dispersed to levels below this low background level before the exhaust reached the terminal, about 2,000 feet away. In fact only some 1,000 feet were needed for the level to be so low we could not measure it. Figure 2-27 schematically shows the setup used to measure these levels.

We also analyzed the data in other ways. EPA standards are written for a 1-hour average for CO, figure 2-28. The contribution of one taxiing Concorde to the pollution level for a 1-hour average was measured at locations as close as 200 feet from the taxiway centerline. We found that its average contribution was less than about one-tenth of one part per million--less than 0.3 percent of the standard. In other words, we would need about 300 Concorde operations per hour on the taxiway to reach levels where the air quality standard is violated.

You may ask what does all this have to do with general aviation? Well, we also attempted to measure the emissions from a few light aircraft in the FAA fleet. I say attempted because we were not too successful. We did get a few readings, but we were not able to accurately define the exhaust from a light plane. I do not want to give you the impression that general aviation aircraft do not pollute at all--they do, at least a little. All, I am saying is that we had a difficult time obtaining good emissions data from them. Actually, I was not surprised, because it was difficult to obtain measurements on the Concorde, which is considered to be a very "dirty" airplane.

One last point about the Dulles measurements, figure 2-29. One of our special setups included three towers like this one--over 80 feet high--with CO samplers at about 15-foot intervals. We used these towers to obtain data on exhaust plume rise. To our knowledge, this was the first good data base ever obtained on plume rise. We found that plume rise is significant--50 feet or more depending on the airplane type. That, of course, means that exhaust concentrations very close to airplanes are much lower than one might expect. The hot air tends to take emissions up--away from people. This factor is not too significant at large distances--say 3,000 feet away from the engine. But, we know that emissions that far away are already dispersed to well below even a clean-air background. The tower data showed that close-in, we have this additional factor going for us and for the people near the terminal.

The Dulles experience allowed us to better define the impact of aircraft on the airport and surrounding community; but for only one airport. We expect, in 2 or 3 months, to have completed a more detailed study of 35 airports. We are gathering all available data on emissions background, activity levels, and so on for the 25 busiest commercial airports and the 10 busiest general aviation airports in the country. We will estimate the contribution from all sources of emissions, factor in traffic growth, and calculate the expected contribution

of aircraft to air pollution at these airports over the next 15 or 20 years. Some of you may remember that EPA did a similar study before they issued the aircraft standards, but considered only two of the airports in our study---Van Nuys and Tamiami. They assumed a 149-percent increase in traffic in 10 years (1970 to 1980) and a substantial reduction in other emission sources. Traffic growth has increased at the rate assumed; however, auto emissions have not been reduced as rapidly as originally anticipated. We now have a better and more comprehensive data base from which to work.

What we want to do is clearly define--as best we can--what the real contribution of aircraft is, to the overall picture. We intend to do this under various assumed levels of aircraft emissions control out to 1990, to see how various levels of stringency on aircraft pollution will affect the picture. I believe a lot of people will be surprised at how modest the aircraft contribution really is, even at the nation's busiest airports.

This brings up another point--air pollution models. We are not satisfied with the current state-of-the-art in airport modeling. We believe some fundamental work needs to be done to improve these models and to make them useful in predicting air polluion concentrations near airports. In 1973, the EPA stated aircraft emissions should be subject to a program of control compatible with their significance as pollution sources. Presumably, since there were no models available to determine the significance of aircraft pollution sources, the 1973 standards were based on EPA's judgment of what reduced emission levels would be practicable to achieve. I think it is time we have a complete reassessment of the situation. Therefore, I have directed my staff to organize a conference --with international representatives from government, industry, and the public sector--to discuss and make recommendations on how we can improve airport models. We intend to closely coordinate this work with EPA and hope they will join us perhaps as a co-sponsor. We believe EPA was correct--standards should be based on the significance of an air pollution source. We believe it is unwise to delay further in developing the proper tools. Frankly, I do not believe it wise to require large expenditures of money--government funds or private capital--based on a judgment of how low emissions requirements should be. I see two basic flaws to this thinking: one, the judgment may be wrong, and second, the cost of achieving low emissions levels may be far higher than the estimate. But, worse yet, is there really a environmental need for such low emission levels?

At the recent NASA-sponsored conference on aircraft emissions, EPA's technical staff recommended that requirements for reduced oxides of nitrogen and hydrocarbon emissions from general aviation aircraft be eliminated. They did point out that this recommendation might not be accepted. Apparently they have done some work which convinced them that the significance of GA emissions of hydrocarbons and NO_x is minimal. This is in agreement with our findings. In addition, we have done some work on carbon monoxide. Our preliminary studies are showing that the significance of GA's contribution to CO pollution is also questionable.

All of these factors may leave you with a question--where does FAA stand? We are working very closely with EPA to help them in any way we can with their analyses. Congress has given them the responsibility to set standards, and it is our job to implement and enforce these standards in a manner which ensures safety of flight. Therefore, we exert a lot of energy on assuming enforceability of the standards. Presently, now, we are working on a number of things, as shown in figure 2-30. We need more information on engine-to-engine variability, installation effects, reliability of low-emission engines, and the effects of wear and maintenance. We also are concerned with validating and simplifying the test procedures and instrumentation. And, before any new engine designs are released, we consider all potential safety factors.

In summary, a few concluding points are:

We believe that there is a real need for improved data, figure 2-31, so that we can quantitatively determine the significance of aviation pollution.

Our programs to date indicate that, if there is an airport pollution problem, it most likely comes from cars used in and around the airport.

We welcome the spirit and substance of the cooperation, we believe, has been established between EPA and FAA in this area.

We place high priority on aircraft emissions in our environmental quality program.

We have concerns about just how practical are our system and test procedures.

We have a long way to go before we can say that we have been able to achieve a truly cost-effective system for general aviation emissions control.

In cooperation with EPA and industry, we hope to move efficiently toward a reasonable and economic solution to the important problem of cleaning up the air.

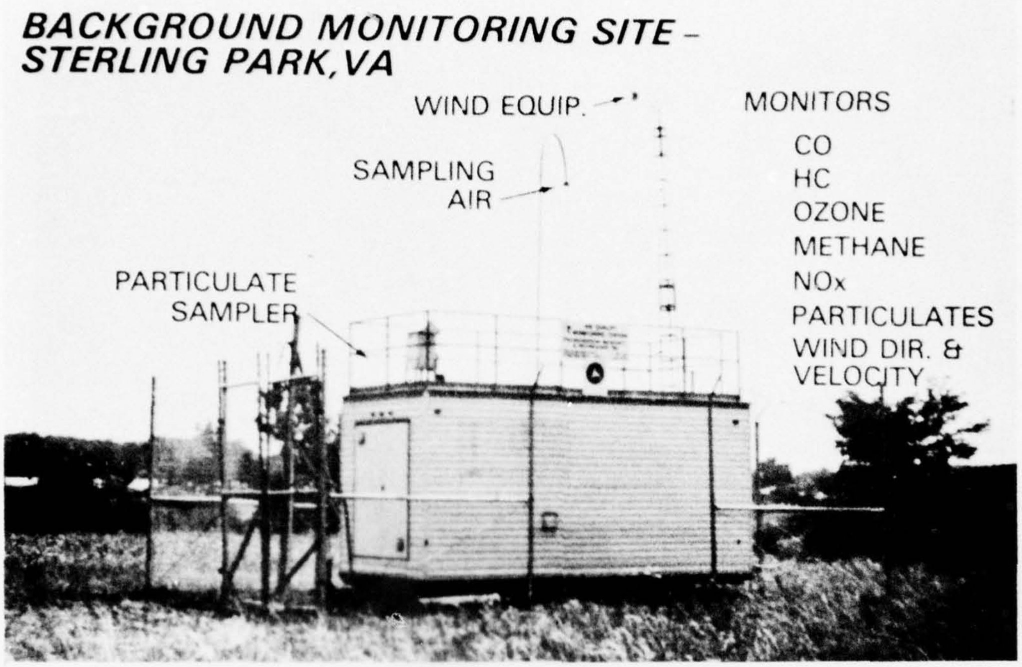


FIGURE 2-24

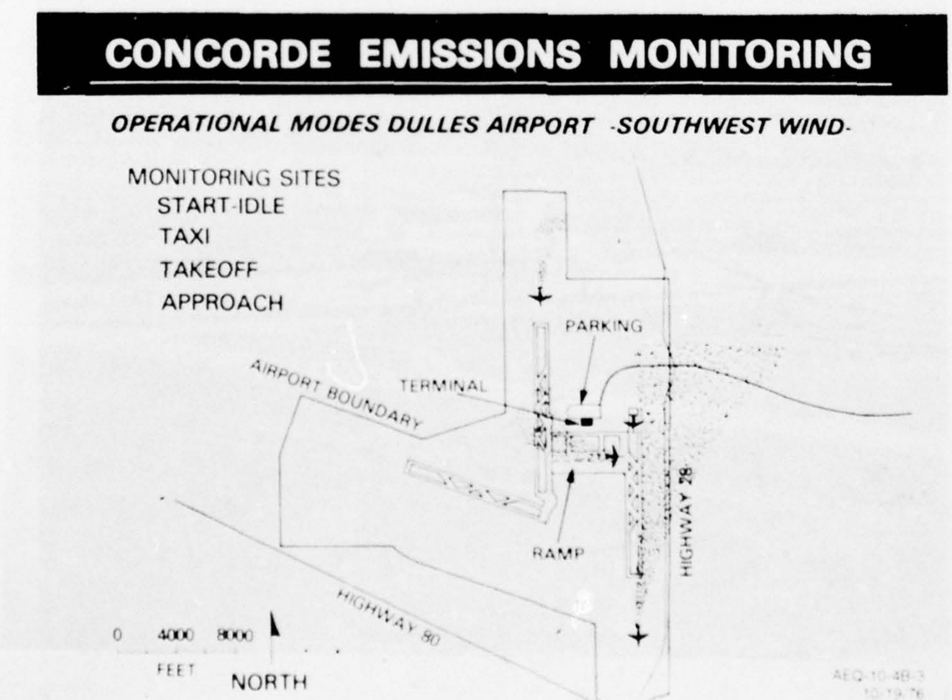


FIGURE 2-25

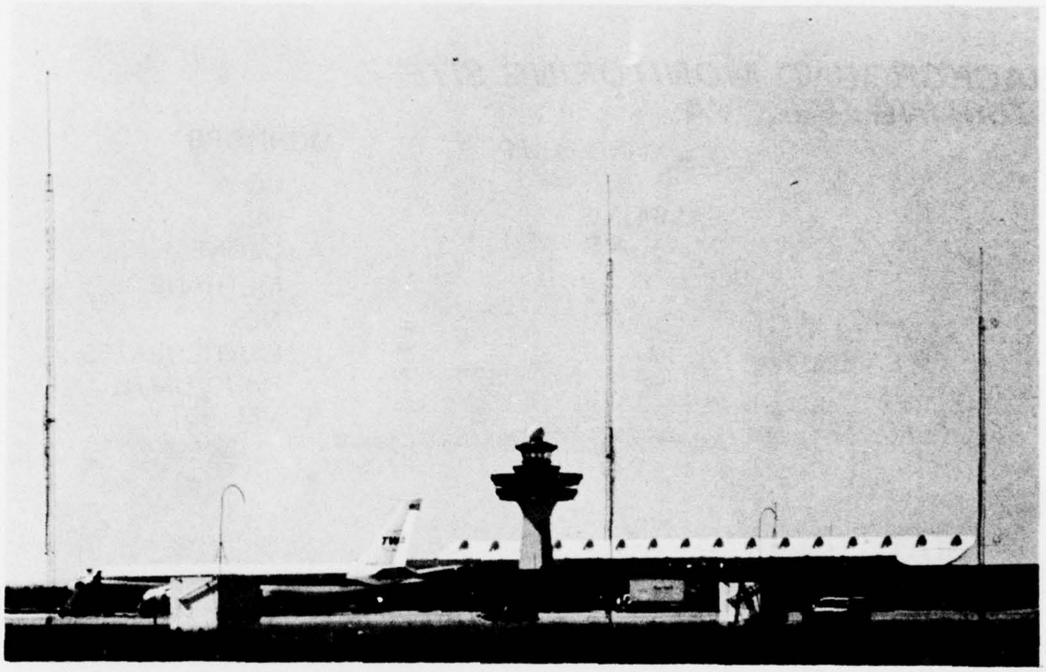


FIGURE 2-26

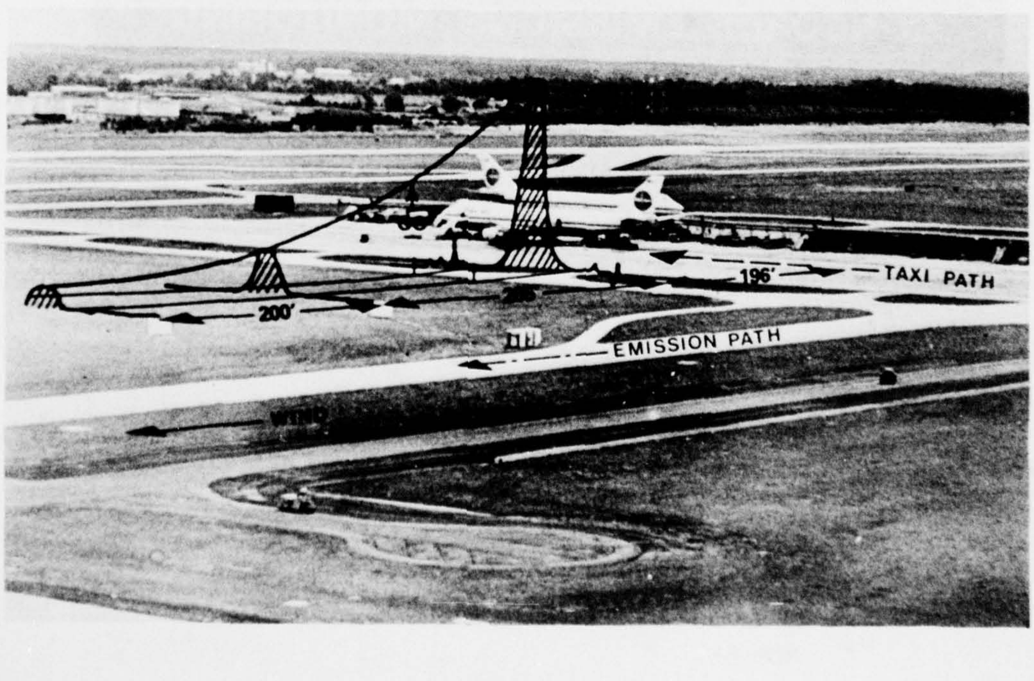


FIGURE 2-27

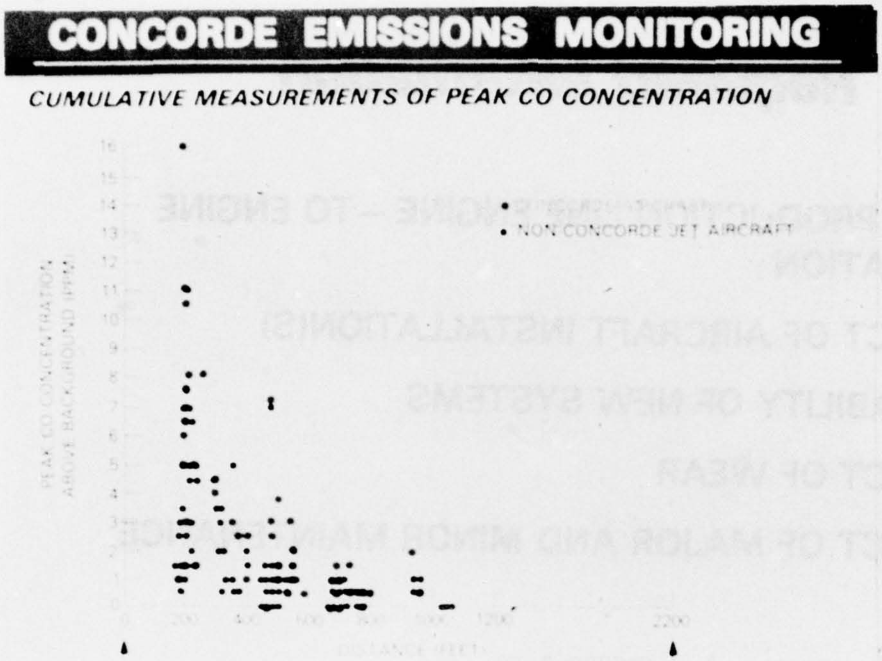


FIGURE 2-28

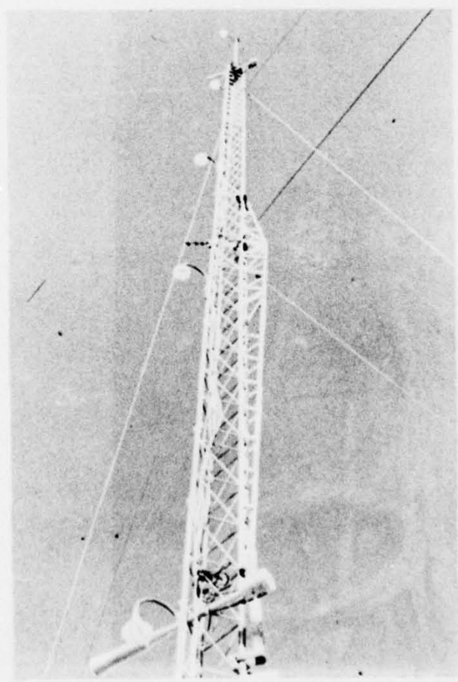


FIGURE 2-29

Required Information

- NEW PRODUCTION LINE ENGINE — TO ENGINE VARIATION
- EFFECT OF AIRCRAFT INSTALLATION(S)
- RELIABILITY OF NEW SYSTEMS
- EFFECT OF WEAR
- EFFECT OF MAJOR AND MINOR MAINTENANCE

FIGURE 2-30

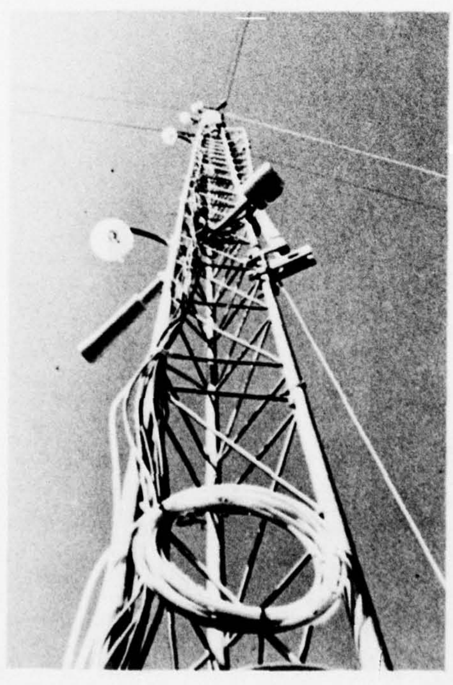


FIGURE 2-31

NEAR-TERM ENGINE EMISSION REDUCTION INVESTIGATION

MR. RICHARD SKULLY

Thank you, Chuck. The next subject will be the near-term engine emission reduction research that we are doing, and the gentleman to talk about it is Bill Westfield. Bill is the program manager on the aircraft engine emissions with Research and Development Service. Bill--

MR. WILLIAM WESTFIELD

Thank you Dick. Chuck Foster has pretty much summarized what the policy stance of the FAA is with respect to aircraft emissions. I would like to reiterate the basis whereby the FAA is actually in the business of measuring piston engine emissions. When the Environmental Protection Agency (EPA) issued its emission standards in 1973, as directed by Congress to find out whether or not there was a health or welfare problem due to aircraft emissions, the Congress also stated that when the EPA made its determinations, the Department of Transportation, or in the case of the aircraft situation, the FAA, would take on the job of enforcing and implementing the standards.

EPA, in its determination that control of aircraft emissions were necessary, indicated that it's promulgating an order so that general aviation piston engine exhaust emissions could be satisfactorily controlled by the use of "better fuel management." The FAA felt obligated to establish the relationship between "better fuel management" practices and operating considerations such as cyclinder head temperature levels, detonation margins, acceleration characteristics, smoothness of operation, etc. Discussions were held with EPA on this subject, and this program of investigation of emissions reduction was undertaken. The FAA realized that "better fuel management" could involve going beyond minor adjustments in fuel schedules, and therefore the assistance of the National Aeronautics and Space Administration (NASA) was enlisted. It was agreed during these discussions that operating existing carburetors or injectors at leaner fuel schedules, altering spark timing, or combinations thereof, would be within the purview of the mission of the FAA. Alterations beyond this were considered to be technological improvements and would therefore be within the mission of the NASA. This discussion will restrict itself to the results of the FAA portion of the work, the near-term reduction capabilities.

Very little was known about the exhaust emission levels of the general aviation piston engine fleet. This being realized, the FAA, with funding support from the NASA, decided to contract with the industry to collect the technical data base necessary for regulation. NASA supported this effort so that the information relative to the emissions of the present-day fleet could be suitably apprised and form a mark beyond which improvements in the future propulsion systems of general aviation aircraft could be targeted.

The FAA eventually contracted with Teledyne-Continental Motors (TCM) and AVCO-Lycoming Corporation to conduct tests on engines that were considered representative of their manufacture to collect the necessary data base. Engines were to be selected under no special conditions. Those to be tested ranged from the relatively simple carbureted types to the injected, turbocharged, and geared types. Figure 2-32 shows the engines that were chosen by the manufacturer and accepted jointly by FAA and NASA. The list is fairly representative of the population of the present-day fleet. Figure 2-33 shows the test stand setup used in the test cells.

Figure 2-34 shows the emission levels that were measured for these engines on the static test stand. All engines were tested with the flight propeller. As can be seen, none of the engines were capable of reaching the level specified by the EPA limits. The details of this static test stand work will be discussed shortly.

Our contracts with TCM and AVCO stated that the optimum achievable level would be identified by each manufacturer. Obviously there was reluctance to go beyond what many years of experience had indicated was proper under the existing safety and performance goals. The EPA limits, however, mandated that a hard look be taken at those margins to see if some could be pared safely.

The FAA contract further stated that after the manufacturers had identified what they felt were production engine emission levels and those emission levels achievable with the use of the leaning technique and altered timing, the identical engines would be retested at our facilities here at NAFEC to first establish the validity and credibility of the manufacturer's data. The FAA then, would, and has, independently extended the leaning beyond the manufacturer's limits to investigate whether the ultimate in emission reduction, at least on the static test stand, had been reached. The next figure shows the emission levels attainable on the test stand at NAFEC and the conditions under which they were obtained, without encountering safety problems. The cylinder head temperature (CHT) increases experienced did not represent significant increases, figure 2-35. As can be seen, all but the turbocharged engines could be adjusted to emit exhaust emissions in conformance with or lower than the EPA limits.

The collection of these two sets of data represents the starting point from which the FAA will make its determinations of what exhaust emissions levels can be reached.

We are now entering the second phase of the determinations through a contract extension of our test stand work with TCM. Injectors which will sense and compensate for temperature and density changes will be investigated to see if even leaner fuel schedules can be safely tolerated to achieve lower emissions.

The overall program to date has consumed more time and funds than had initially been estimated. It was found very early in the program that problems existed for which solutions had to be obtained before the data could be considered reliable. Figure 2-36 lists some of the more serious problems encountered. It will be helpful if a short explanation is given of why we considered these to be serious.

The initial goal of the work was to produce data that were credible. We structured the replicate testing to give this confidence. Unfortunately, each group in the test program had its own peculiar set of contributing effects. TCM, AVCO, and NAFEC are located in regions of varying altitudes, average temperatures, and humidities. The task of determining the impact of leaner fuel schedules on emissions was complicated by these variations in temperature, pressure, and humidity to such a degree that cross-calibrations of both airflow and fuel flow measurement systems at each facility were necessary before comparison of the data was successful.

The next listed problem area has not been fully resolved, although agreement between the various emission equipment sets is felt to be acceptable. These equipment sets are all basically laboratory-type equipment, and their use in an operational test environment is still uncovering new facts that can distort the interpretations of the resultant data. The FAA has fabricated two mobile sets of emission measurement equipment, one of which is available for inspection nearby. These equipment sets are fully mobile, and in the event testing at certification is the only requirement, two sets should suffice. In the event more than certification testing becomes necessary, simplification and ruggedizing (ruggedness) of the measurement equipment will be necessary. To minimize these equipment problems, the industry and goverment have recently combined their efforts under the sponsorship of a Society of Automotive Engineers Subcommittee to develop an Aerospace Recommended Practice describing the whole process of collection, calculation, and analysis of exhaust emission data taken from aircraft piston engines. (This ARP will be presented to the full SAE committee for review and approval in the early fall of 1977.)

Consistent and accurate calibration gases is another problem that is not fully resolved. While we now understand that effects due to storage time, storage container material and storage temperature must be carefully controlled. The calibration gas technology is still the result of efforts made for other industries such as stationary sources and automotive sources. The calibration gas values that are needed in the aircraft piston engine field are sometimes outside the range needed for the other sources where the bulk of research and development (R&D) has been conducted to produce accurate, reliable calibration gases. There is a strong need for standardization of the calibration gases used in this aircraft field. Such work has been identified for National Bureau of Standards Considerations.

The last problem area is one that will hopefully be circumvented by the newly developed ARP. The ARP does consider many of the individual problems encountered in the replicate testing at TCM, AVCO, and NAFEC. For instance, it was found that differences in emission levels for a landing-takeoff-cycle calculation would vary considerably depending upon the length of time spent at the initial idle-power operating point. The engine, inefficient at this low speed, tended to load up with oil, and when the next power point, taxi, was set, the emissions level would remain abnormally high, longer than the time specified for stabilization and collection of data, and consequently, high levels of emissions would be introduced into the full-cycle calculations. It eventually was noted that elimination of data-taking at the idle power could be tolerated if the time

normally associated with idle was assigned to the taxi power. The overall emission level for the LTO cycle calculation as calculated both with and without the actual idle data was basically unchanged. The FAA therefore feels confident in recommending deletion of the requirement for taking actual idle-power data. The ARP, in circulation for approval, reflects this recommendation.

There are other areas that have not been listed as specific problems but are of strong concern to the FAA. A considerable number of general aviation airports are located at altitudes that are in excess of 3,000 feet. In fact, a great number are over 5,000 feet, and some are as high as 10,000 feet. We have noted that engine operation at these reduced density levels results in higher cylinder head and exhaust gas temperatures. The higher CHT problem is obvious; the reduced or leaner fuel schedules developed on the sea level test stand cause some increase in CHT which can be accepted. However, coupled with reduced density such as the high-altitude airports present, the increase in CHT is emphasized and may become unacceptable. An engine demonstrated on the manufacturers test stand as being acceptable emission-wise and within CHT limits with a lean fuel schedule could encounter operating problems when operated at altitudes that are unacceptable safety-wise.

The second part of the effect of lower density, that of increased exhaust gas temperatures, is more subtle. There is concern with respect to the use of exhaust gas heat exchangers for cabin temperature control. The levels of EGT we are projecting can be at or beyond the limits of the metals used in the present exchangers.

These two unlisted problems lead us to figure 2-37, future activities. The EPA standards include a requirement that all in-use engines continue to be in compliance with their standards throughout the engines lifetime. As you may see in the tours later, we are presently conducting tests at NAFEC to examine, in a preliminary fashion, what changes in emission level can be expected with engine operating time, figure 2-38. This pilot program is the precursor to a larger scale contractual effort for which we are presently requesting proposals. The pilot program is designed to guide us in our setting of requirements for the RFP so that the proper variables are examined and considered. Additionally, we expect to do a first-cut look at what different types of maintenance may do to the emission levels. Two aircraft, a Beech Baron and a Seneca-2, are being monitored for emissions levels every 25 hours, figure 2-39. Between measurements, the aircraft operations are normal and uncontrolled, but are documented in detail. Emissions data are expected to be obtained both before and after instances of minor and major maintenances. These pilot data will be analyzed to direct the collection of information at proper times and locations during the contractual effort. This impact of maintenance is also a part of the contractual effort.

As our test stand work with TCM produces results, they will be incorporated into engines, and later in this year, the most promising of the test stand improvements will be incorporated into actual installations for investigation under simulated flight conditions here at NAFEC. For the culmination of the total work, we have the capability of operating the aircraft in wind streams as high as 150 knots and at temperatures equivalent to hot/dry operation.

Those modifications that prove successful here will be used in the flight demonstrations of the modified engines in actual installations to assure safe operations while achieving low emissions.

This discussion has focused on the work in the piston engine area. The FAA has a parallel R&D effort for the turbine engines which has been underway for several years. Again, the FAA is examining the characteristics of the present-day operating aircraft, and the NASA is concentrating on the advanced technology developments for reduction of the emissions.

This effort by the FAA incorporates the objectives, namely the development of measurement systems, identification of proper test procedures, establishment of the emission levels of the population of the fleet, and the impact of operating time and maintenance on emissions.

Since the FAA is legally bound to enforce emission limitations, the R&D test and evaluations of engines will be a continuing effort. The work will continue to strive to allow safe reduction of emissions so that the fleets of aircraft will remain harmonious with the environment.

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PROCEEDINGS OF THE FAA GENERAL AVIATION RESEARCH AND DEVELOPMEN--ETC(U)
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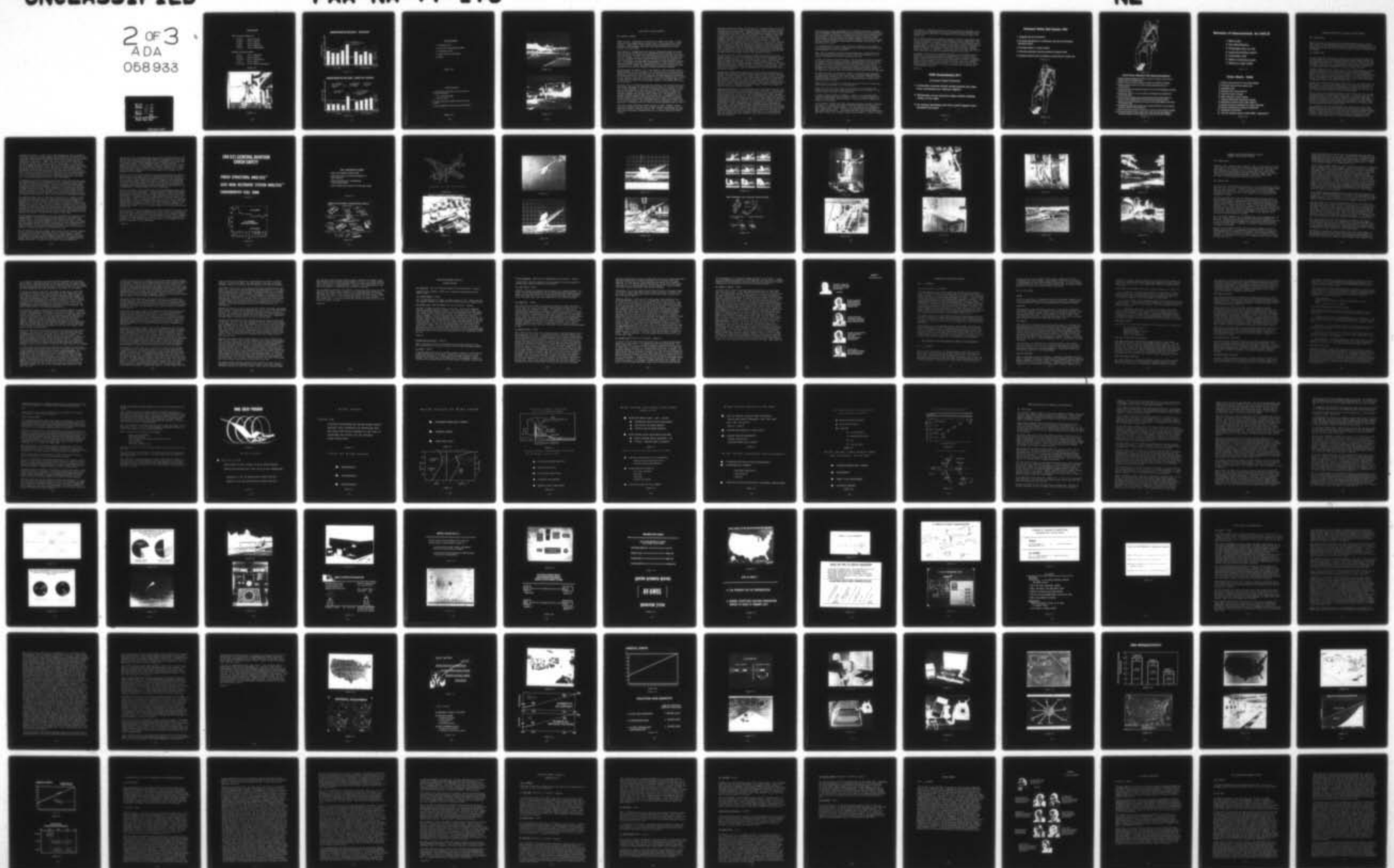

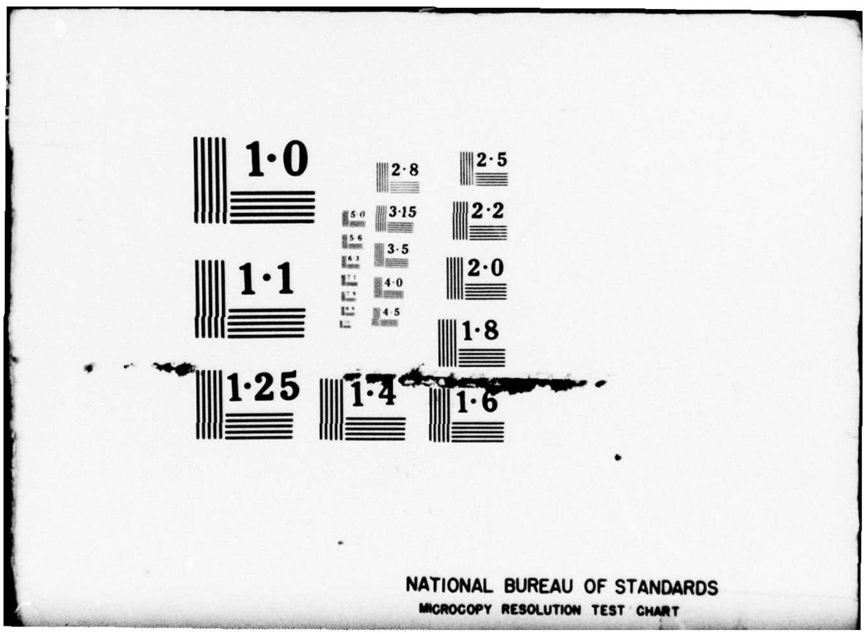
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NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

ENGINES TESTED

AVCO-LYCOMING CORPORATION

IO-360-A,	200 HP, INJECTED
IO-360-B,	180 HP, INJECTED
IO-320-D,	160 HP, INJECTED
O-320-D,	160 HP, CARBURETED
TIO-540-J,	350 HP, TURBOCHARGED

TELEDYNE-CONTINENTAL MOTORS

O-200-A,	100 HP, CARBURETED
IO-520-D	300 HP, INJECTED
TSIO-360-C,	225 HP, TURBOCHARGED
6-285-B,	285 HP, GEARED
GTSIO-520-K	435 HP, GEARED-TURBOCHARGED

FIGURE 2-32

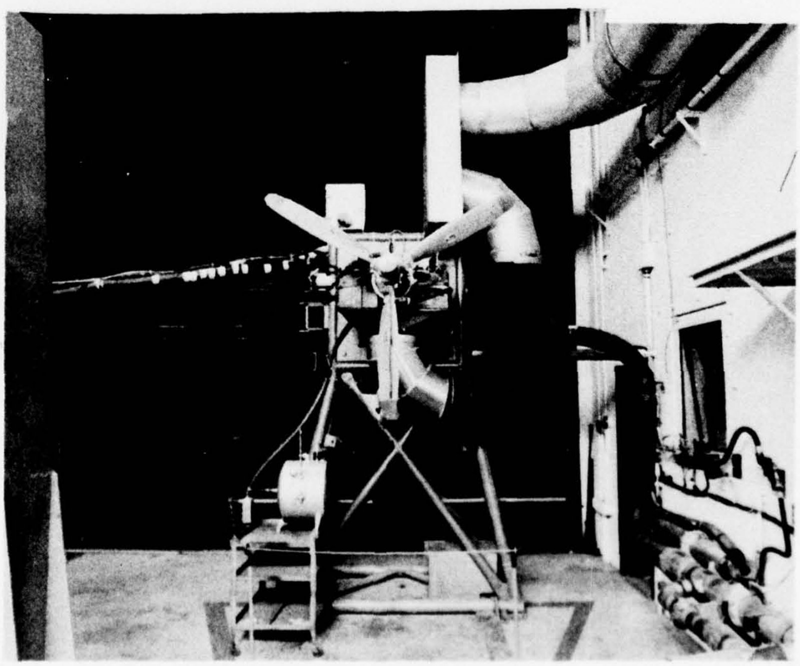


FIGURE 2-33

CARBON MONOXIDE EMISSIONS – AS RECEIVED

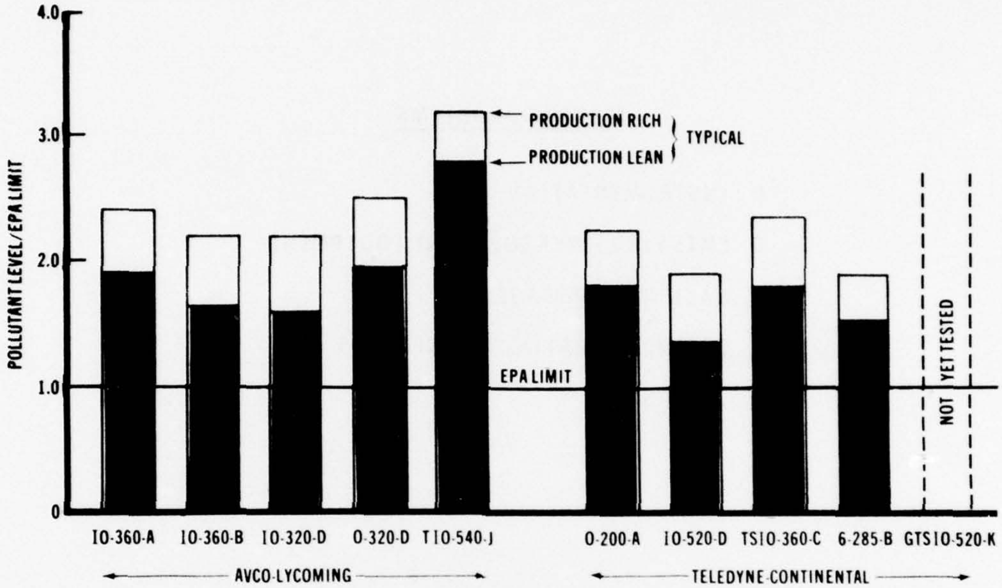


FIGURE 2-34

CARBON MONOXIDE EMISSIONS - LEANED FUEL SCHEDULE

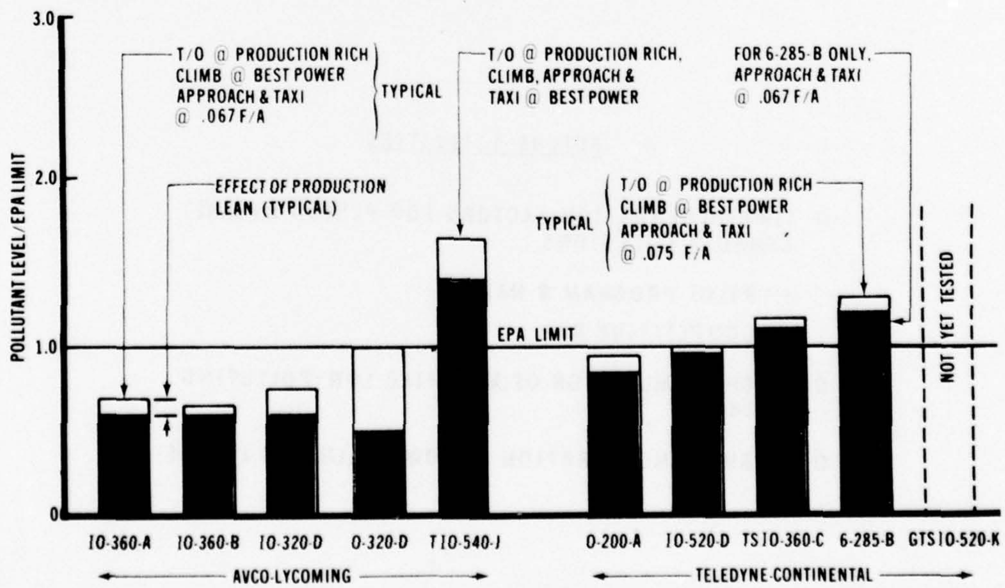


FIGURE 2-35

TESTING PROBLEMS

- O INSTRUMENTATION
- O EMISSIONS MEASUREMENT EQUIPMENT
- O CALIBRATION GASES
- O ENGINE OPERATING PROCEDURES
- O OTHERS

FIGURE 2-36

FUTURE ACTIVITIES

- O TIME-DEGRADATION FACTORS FOR PISTON ENGINE EXHAUST EMISSIONS
  - -- PILOT PROGRAM @ NAFEC
  - -- COMPETITIVE RFP
- O FLIGHT SIMULATION OF MODIFIED LOW-POLLUTING ENGINE
- O FLIGHT DEMONSTRATION OF LOW-POLLUTING ENGINE

FIGURE 2-37

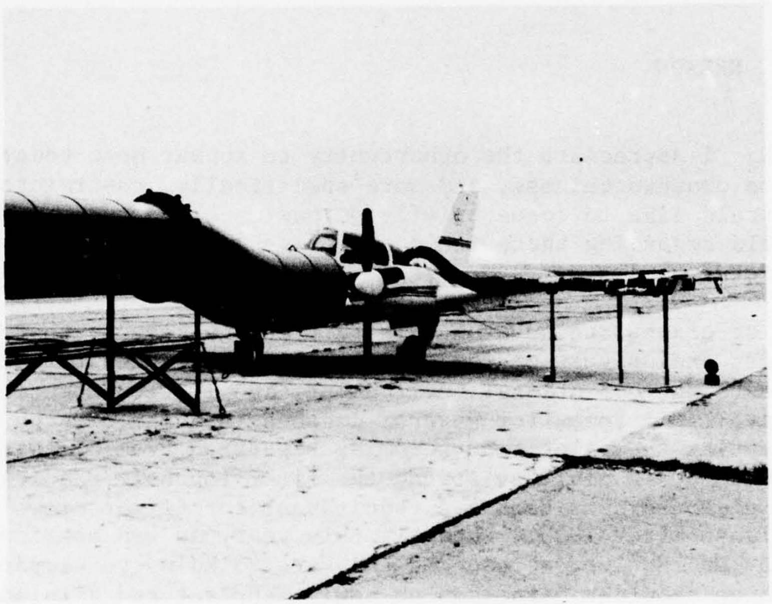


FIGURE 2-38

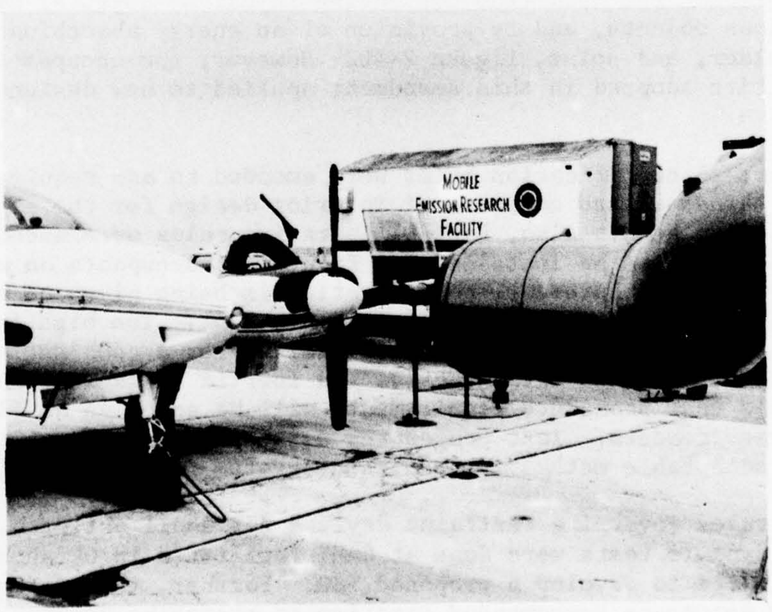


FIGURE 2-39

CABIN SAFETY BY CRASH SURVIVAL

MR. RICHARD W. NELSON

Thank you Dick. I appreciate the opportunity to appear here today. I would like to discuss crashworthiness, and more specifically, restraints and crash survival. I would like to focus briefly on past achievements in the crashworthiness field regarding these items and present an overview of current projects and future goals.

Early history of crashworthiness and aircraft design reveals that the primary focus was almost exclusively on the airworthiness safety features of the aircraft relative to the operational environment, and little attention was devoted to crash survival. In fact, for several decades in aviation, the concern was more for preventing the pilot from becoming separated from his airplane than for crash survival. In civil aviation, the first lap belt requirement was in 1927. The shoulder harness became a requirement for flight crews and transport category airplanes after 1968. Recently this year, as was mentioned earlier this morning by Dr. Mohler, we amended FAR Part 23 Rules to require front-seat occupants to have shoulder harnesses on newly manufactured airplanes.

Exploring modern development, Part 23 was amended in 1969 to upgrade numerous design standards for small airplanes. One important standard required the protection for the occupant from head injury by three means: by shoulder harness, which would prevent the head from contacting injurious objects; by elimination of the injurious objects, and by provision of an energy absorbing rest to support the arm, shoulder, and spine, figure 2-40. However, the occupant impact protection objective adopted in this amendment applied to new designs only and was not retroactive.

This year, Part 23 certification rules were amended to add requirements concerning shoulder harnesses and compartment interior design for the type certification of small airplanes. Also, Part 91 operating rules were amended to require that shoulder harnesses be installed for front-seat occupants on newly manufactured airplanes. At present, consideration is being given to amend the technical standard order for seat belts, figure 2-41. The highlights of the proposed Technical Standard Order for seat belts are: a combination lap belt shoulder harness, metal to metal buckles and inertia reels will be provided, and new dynamic test procedure requirements will be added as an alternate for static test requirements. Test procedures exist in an Advisory Circular which describes an acceptable method for restraint system installation (AC No. 4312-2).

There are no rules governing restraint devices for small children, although considerable dynamic tests were done at CAMI facilities in Oklahoma City, and there is a project to develop a proposed TSO. Further, there's been available since 1967 an Aerospace Recommended Practice on restraint devices for small children.

Regarding function and design, the function of a restraint system is to protect the occupant, of course, in the crash environment. Restraint systems are classified as passive or nonpassive. Examples of passive types would be air bags, or padded cabin interiors, or any such system where the occupant does not have to initiate any action to receive the protection. For a nonpassive type, the occupant would have to initiate action to receive the protection, such as buckling a lap belt. For sake of definition, a lap belt is a single belt extending across the anterior aspect of the pelvic structure. A seat belt system (this is new nomenclature) is any combination of lap and torso restraint. Over the years, the simple web lap belt has contributed effectively to protection of occupants in the crash environment. However, it does not provide the degree of body support that the combination shoulder harness lap belt system does. Although the occupant is restrained, and prevented from a flailing about to a certain extent, he still can be subjected to jack-knifing action and submarining, and for this reason we prefer the combination system.

The lap belt/shoulder harness configuration depicted in figure 2-42 is the superior system. It is the kind used for airline transport systems and on some general aviation aircraft. It is superior in that it is a comfortable system with the single-point buckling. It has five attach points, crotch strap, shoulder harness, and lap belt, but with a single point buckling. It is very simple and easy to use. Further freedom of movement and accessibility to flight controls is provided by having an inertia reel in the shoulder harness. The crotch strap functions as a lap belt holddown device and transfers the load to the pelvic structure.

The restraint system shown in figure 2-43 is a much simpler system, which is probably more palatable to general aviation usage, due to its comfort and simplicity. It should stimulate the occupant to use the total system at all times, which sometimes is a problem. Use of metal-to-metal buckles are encouraged on new restraint designs due to its positive locking, independent of load. The metal-to-fabric cam-type buckle may allow the webbing to slip through the locking device or cam, either partially or totally. This type of buckle has been, for the most part, eliminated in transport category airplanes, but plenty of them are still used in General Aviation.

Regarding crash survival, it is interesting to note that despite the fact that the military had devised restraint systems prior to World War I, and were using them, and despite the fact that there were regulartory requirements for crash survival as far back as 1927, the field of crashworthiness, itself, remained rather dormant until World War II. The first systematic study of crash survival was initiated by the Crash Injury Research Unit at Cornell University in 1942. Working with government and industry, the research unit developed 10 significant recommendations which raised radically new crashworthiness features for aircraft design. These recommendations are now shown for your information in figure 2-44. In 1949 at Texas A&M these recommendations and other radically new crashworthiness features were used in design and fabrication of an airplane known as the AG-I, which (although short-lived, since it was the only one built) crashed without injury to pilot. It nevertheless became the forerunner for most of the aerial applicator airplanes flying today. Our records indicate that such airplane types have exhibited a very fine track record as far as safety is concerned.

For the most part, these recommendations are considered applicable to general aviation passenger airplanes as well, and can be reduced to two basic principles: one is protection by provision of adequate restraint within the occupiable area, and the second is the provision of crush-proof structure around the occupant. Incorporation of these principles into design of general aviation aircraft should provide the degree of impact protection necessary for survival and insure that the occupant is capable of affecting his own escape, which is what crashworthiness is all about.

It is interesting to note that, from a historical standpoint, that although 35 years have elapsed, these recommendations are still valid and indicate areas where improvement can still be realized.

Major work on emergency evacuation escape procedures was accomplished by the Civil Aeromedical Research Institute in 1950. This work subsequently led to new exit requirements and improved exiting capabilities.

In 1958, as a result of work with Cornell, Civil Aeromedical Research Institute and manufacturers and operators involved a delethalization and the protection of occupants, the FAA recognized certain accepted practices to be used in conjunction with interior evaluations. These practices apply to head-strike distance of seated and belted occupants in proximity to bulkheads, tables, and protuberences. This work also concerned what constituted suitable padding. The head-strike distance within the specified delethalization zone was prescribed.

In February of 1973, the FAA issued a summary of crashworthiness information for small airplanes which reflected much useful information regarding seats, delethalization, restraints, etc. The document was geared to assist the small airplane designers in developing their own acceptable means to handle their particular safety problems.

Figure 2-45 lists a summary of improvements for Part 23 that have taken place over the years, especially in air taxi operation.

Figure 2-46 lists the future needs, most of which are being handled under research projects from which regulatory improvements can be obtained. As you can see, there's much work to be accomplished.

At present, Flight Standards is engaged in support of the FAA-NASA general aviation crashworthiness program, where the goal is to improve occupant protection in a survivable crash environment. I will only briefly summarize the subparts of this program.

The FAA supports research activities involving seats which includes a "man seat math model." A 3-dimensional computer model that simulates the response of seat, occupant, and restraint system to a crash environment was developed for FAA by Ultrasystems in 1972. Presently, this program is being validated by CAMI, NAFEC, and Penn State. It is understood that copies of this program have been sent to Piper, Bell, Rockwell, Cessna, Navy, and NASA. In 1975, a contract

was awarded to Lockheed and Cessna to develop a program with objectives to perform structural crashworthiness analysis of general aviation airplanes during probable accident conditions. This program is in the validation stage at the present time.

Also in 1975, a contract was awarded to Grumman to develop a mathematical model for crash simulation of aircraft structures using a finite element code. This program is presently in progress, and we understand the data developed thus far are satisfactory. Since implementation of the general aviation crashworthiness program, NASA has crash tested several general aviation aircraft at Langley Research Center and has obtained relevant crash data on fuselage structure, seats, and dummies. In addition to various low-wing tests, three high-wing airplane crash tests also have been conducted this year for the FAA.

In summary, I have traced the FAA-CAA involvement in civil aviation and the evolution of the regulations regarding crashworthiness. The intent was to explore areas needing improvement and recommend acceptable methods to improve safety. Areas of concern and future goals were shown. Presently, considerable effort is being expended in various research programs such as the FAA-NASA general aviation crashworthiness program. It is anticipated that the results of these programs will enable us to develop technical data and improve the crashworthiness standards.

Thank you.

FAR Amendment 23-7

Occupant Head Protection

1. **A shoulder harness which would prevent the head from contacting any injurious objects**

2. **Elimination of any injurious object within striking radius of the head**

3. **An energy absorbing rest that would support arms shoulder and spine**

FIGURE 2-40

Proposed Safety Belt System TSO

1. Upgrade lap belt standards
2. Provide standards for combination lap belt and shoulder harness system
3. Provide metal-to -metal buckles
4. Provide automatic locking retractors (inertia reels)
5. Require dynamic test procedure as alternate for static test

FIGURE 2-41

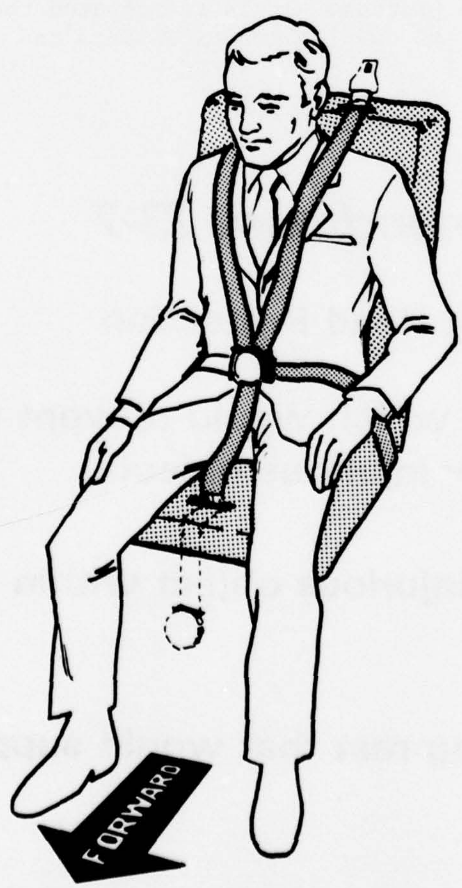


FIGURE 2-42

FIGURE 2-43

Crash Injury Research Unit Recommendations

1. **Design forward fuselage and cabin structure to restrict crash loads as well as flight and landing loads**
2. **Design aircraft structure to absorb energy by progressive collapse**
3. **Design tubular structure to bend and fall outwardly away from the occupants**
4. **Locate the pilot and passenger seats as far aft in the fuselage as possible behind the wing**
5. **Locate fuel tanks in, or on, the wings, not between the firewall and instrument panel**
6. **Provide space between the instrument panel and forward section to permit forward displacement of the panel and instrument cases**
7. **Design the instrument panel to be free of sharp rigid edges in the range of the pilots head**
8. **Fabricate the instrument panel of soft ductile material or use an energy absorbing shield on the panel face**
9. **Mount instrument cases on shear pins or as low on the panel as possible**
10. **Provide shoulder harness, safety belts, seats and seat anchorages of sufficient strength to resist failure up to the point of cabin collapse**

FIGURE 2-44

Summary of Improvements for FAR 23

1. More exits
2. Exit identification
3. Passenger door an exit
4. Improved locking means
5. Evacuation test
6. Better overwing access
7. Minimum aisle width

FIGURE 2-45

Future Needs - Goals

1. Crash environment for structural design
2. Preclude internal fuel system fire
3. Modified fuels
4. Integral tank improvements
5. Improved seat strength
6. Seat restraint system design
7. Energy absorbing instrument panels
8. Eliminate puncture type cabin objects
9. Smoke/toxicity standards for cabin materials
10. Smoke inhalation protective equipment
11. Passenger motivation
12. Review designs against CAM 3.386-1, appendix B

FIGURE 2-46

IMPROVED SURVIVABILITY FOR GENERAL AVIATION AIRCRAFT

MR. RICHARD SKULLY

Thank you, Dick. Our next subject kind of complements the one that we just heard, and it concerns improved survivablility in general aviation aircraft. And to discuss it is Dick Kirsch who is Chief of the Aircraft Design and Criteria Branch and in the Aircraft Safety and Noise Abatement Division with Research and Development.

MR. RICHARD KIRSCH

The basic areas that I am going to concentrate on this afternoon, figure 2-47, are the mathematical model for general aviation crashworthiness, the man/seat/ restraint system model, and the crash-proof fuel system. The basic reason for the programs are fatalities. We keep having 1,300, 1,400, 1,500 people killed every year, figure 2-48, and we believe these three programs, in combination or perhaps individually, depending on the final outcome, will help.

The basic mathematical model, figure 2-49, for the crashworthiness of the total aircraft is made to cover all three axes, the accelerations, displacements, velocities involved in a full-scale crash scenario. The basic mechanism that will be used, once the computer model is validated, is to iterate back and forth early in the design phase so that a manufacturer, prior to having sealed his design, can optimize it for crashworthiness, and at that point he has a means of compliance because he has already done the job.

Further illustrating the three tasks, figure 2-50, is the fact that we have the users manual. It has been distributed, and is currently being critiqued. In the interim, we are proceeding with NASA-Langley to verify different parts of the model, and finally, when the verification is acceptable, we will put out a total crashworthiness analysis and the final users manual.

This is a very old and simplified version of how the math model tries to model a high-wing general aviation single-engine plane. It basically joins discrete lumps (you can see the dark points in figure 2-51 are specific lumps that represent the masses of the airplane). They are connected by finite elements, and then the responses are just a simple spring mechanism. And this is much easier to run than the finite element model that Grumman is developing, which is quite someways away from being available.

In a cooperative effort with NASA-Langley, they modified their lunar lander simulation facility as you see in figure 2-52, some 300 feet long and roughly 380 feet high, and we can pull back to this point to simulate a general aviation airplane. Langley was able to get about 24 flood damaged aircraft at a very good price, and we were able to get three aircraft, so there will be about 27 total aircraft frames tested. There are also some components that are

available for testing. A closer view of that airplane just prior to launch is shown here, figure 2-53, using a simple pullback mechanism. We removed the tail to minimize the aerodynamic interference, and now we go through the crash sequence. Figure 2-54 is just prior to impact, and look at that for second, but more interesting is figure 2-55. Figure 2-55 is pretty well into it there, and we are able to get data up to about two-tenths to three-tenths of a second into the crash through the umbilical cord, which is all we need to verify this model. And it is working very well to date. The aircraft is pulled aside in figure 2-56 for people to view carefully; you can see there is pretty extensive damage, because that was one of the more severe tests--about 60 mph and about 35° nose down. And just to complete how the test sequence is done, you follow figure 2-57 top row left to right, middle row left to right again, and finally the bottom row. We are filming these crashes with a high-speed camera with timing marks which are analyzed subsequently as well as real time readouts.

To complement the aircraft crash model itself and to help comply with the rules that Dick spoke about in his presentation, we have developed this man/restraint/seat model. The man in figure 2-58 is basically a simplified version, again, of lumps joined with finite elements. We are now able to model six different combinations of seat belt and shoulder harnesses; so I think we have everything a designer would want or need. The seat model uses a finite element, and we have six variations of the leg attachments. So I believe you can put the man/restraint systems and the seat plus the output of the general aviation crash of the airplane itself together to obtain real foundation for improving the designs.

To verify this model, which, as Dick said, has been sent to a number of people for comments, we used a static test, figure 2-59, right here at NAFEC to calibrate and crush the seats, and we are having dynamic tests done at CAMI in Oklahoma City. This is a parallel effort, since the airplanes are being crashed anyway to get real time data. We have the dummies instrumented in each of shots that NASA is conducting. Figure 2-60 is just prior to launch, and in figure 2-61, I thought you would be interested in postcrash situations right after the aircraft came to rest. It is pretty hard to see, but there's your control wheel, there's been some crushing of the cabin area, the seat is pretty well deformed here, some tearing, and the dummy. He did not fare to well in this crash.

The last program is very promising. U.S. Army helicopters had a problem in both crashworthiness, fire fatalities, and ballistic protection, obviously in the Vietnam conflict. The Army developed some very effective fuel cells. Unfortunately, they are quite heavy compared to the current civil cells. But we took that same design, removed the ballistic protection, and had a manufacturer prototype in three-ply, two-ply, and one-ply configurations. As you can see, in figure 2-62 there are some heavier fittings, and this figure is just to give you a feel for the size and shape of the cell when laid out.

Now you take these cells and obviously, again, figure 2-63 is a typical installation of a cell in the wing and without the cells I don't know if you can see the shutoff valve up there. These happen to be triggered lanyard. They can be triggered by inertial switches or whatever turns out to be the most reliable system. And of interest, there have been absolutely no fire deaths in any so-equipped helicopters. So there is a real payoff from the standpoint of

gasoline-fed fires. We installed the tanks, and here in figure 2-64 is a setup that you will be able to see on Friday. There is a standard cell in one wing, and then one of the experimental cells full of colored water in the other wing on the NAFEC Catapult. This viewgraph is prior to launch, obviously. In figure 2-65, we have the initial impact, and you can see the aircraft is going through some poles here, and then we had a number of rockpiles just to make a very severe impact into an incline of earth. Figure 2-66 gives you a closeup view of the type of damage this aircraft sustained with no leakage, but the standard cells did rupture.

So we are now in the situation where we are basically validating the fuselage model as well as seat model, and we are almost finished with the tank test. Since the one-ply cell did work, we are proceeding to try to get a one-ply cell that is slightly lighter, which will take us a few weeks to get manufactured, to see what the lightest weight-least expensive change that can be performed to give that kind of protection. As each of these programs is completed, we will report the results and design criteria, the means of compliance, when that is appropriate, to Flight Standards for their consideration.

There are two areas I like to mention that we aren't progressing on, but there has been some interest expressed. I would be pleased if someone would comment. One is general aviation propellers. The new propellers, or most of the current propellers for that matter, are fairly light, thin metal, and they are not very nick tolerant. I understand we lose a goodly number of them on takeoff, and they do cause a number of incidents--luckily not too many deaths. We have been contemplating a look at the maintenance and repair practice. Could a more tolerant propeller be required so that you still have the same efficiency or maybe slightly higher aerodynamic efficiency but a less susceptible propeller to foreign object damage? There is no active program, but we welcome some opinions from the user.

The other area that has been brought to our attention recently is the need for an annual inspection. Right now everybody has to have one, but these airplanes run as you well know from fairly simple to quite complex, almost transport category types, and there is a potential to set a finite number of hours for an inspection or maybe a localized inspection in different zones of aircraft during the type certification. This approach would be in some ways a more economical and probably well received, if it was warranted.

I thank you.

184-521 GENERAL AVIATION CRASH SAFETY

CRASH STRUCTURAL ANALYSIS *

SEAT/MAN RESTRAINT SYSTEM ANALYSIS *

CRASHWORTHY FUEL TANK

FIGURE 2-47

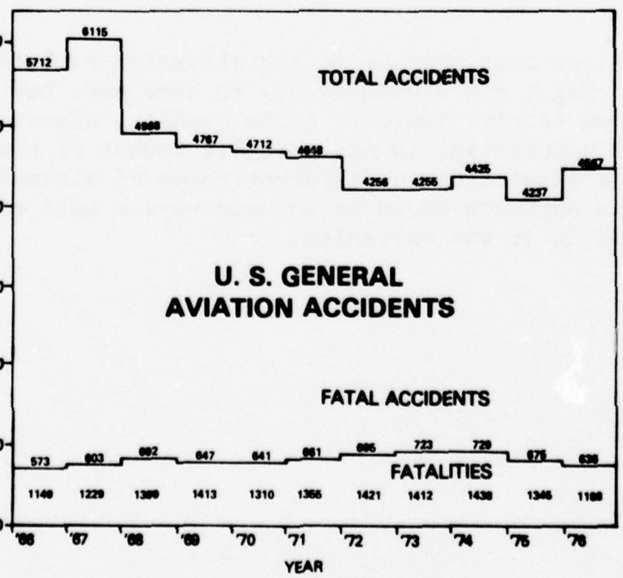


FIGURE 2-48

TASK I MATHEMATICAL MODEL

1. DEVELOP A THREE-DIMENSIONAL MATHEMATICAL MODEL.
2. PREDICT FORCES, VELOCITIES, ACCELERATIONS, DISPLACEMENTS, ETC. ALONG THE THREE AXES.
3. SIMULATE VARIOUS CRASH IMPACTS AND CONFIGURATIONS OF GENERAL AVIATION AIRPLANES.
4. SIMULATE SURVIVABLE CRASH CONDITIONS AND THE ENTIRE CRASH SEQUENCE.

FIGURE 2-49

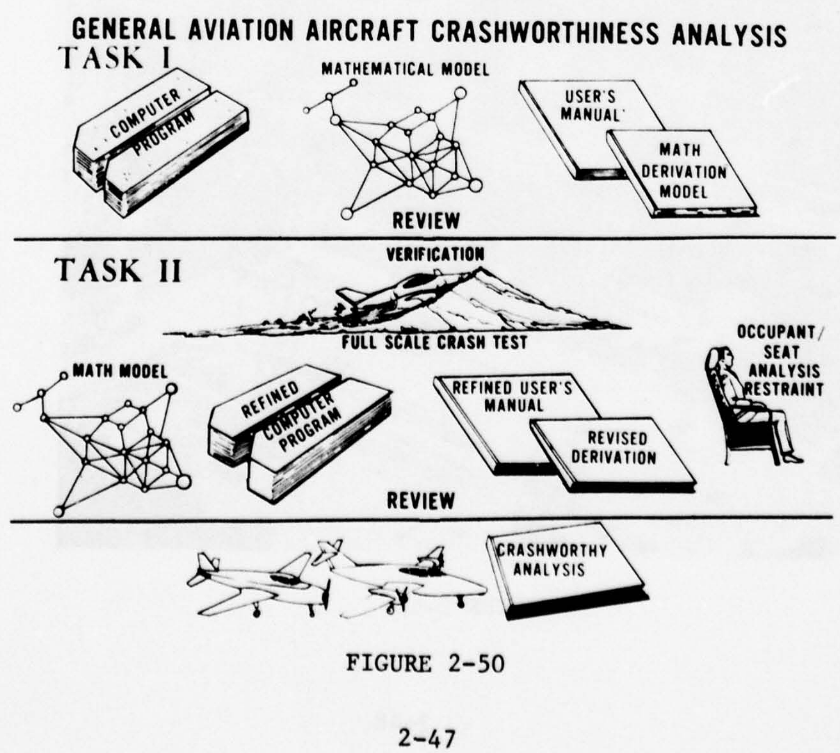
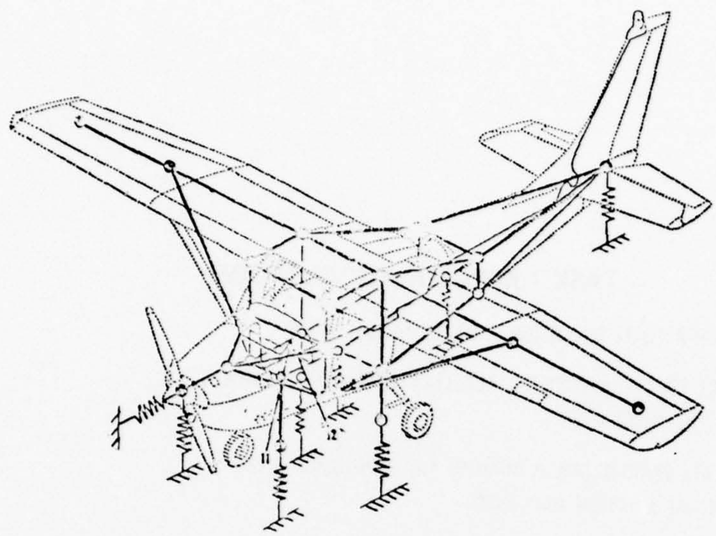


FIGURE 2-50



Preliminary Lumped Mass Model of a Typical Single Engine High Wing General Aviation Airplane

FIGURE 2-51

IMPACT DYNAMICS RESEARCH FACILITY

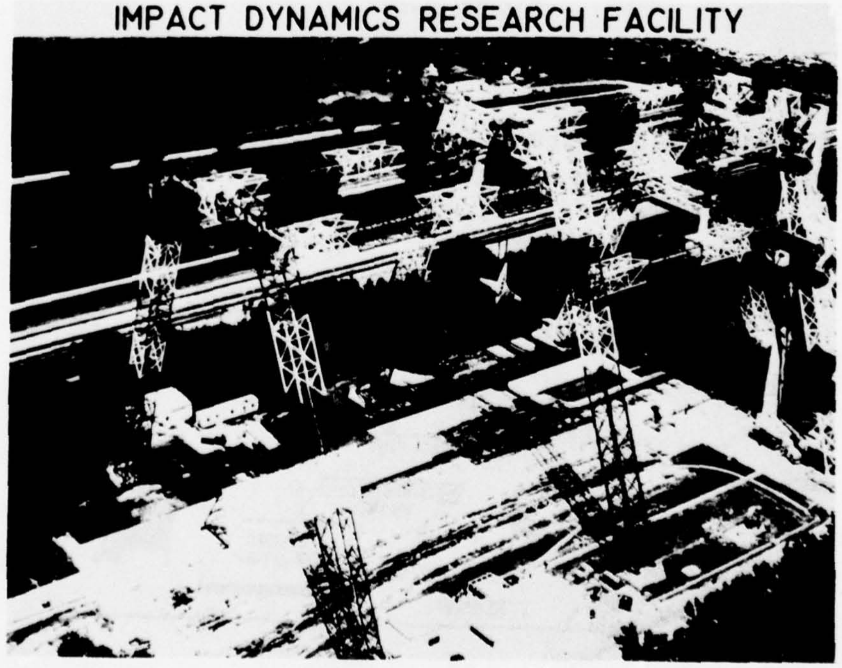


FIGURE 2-52

FIGURE 2-53

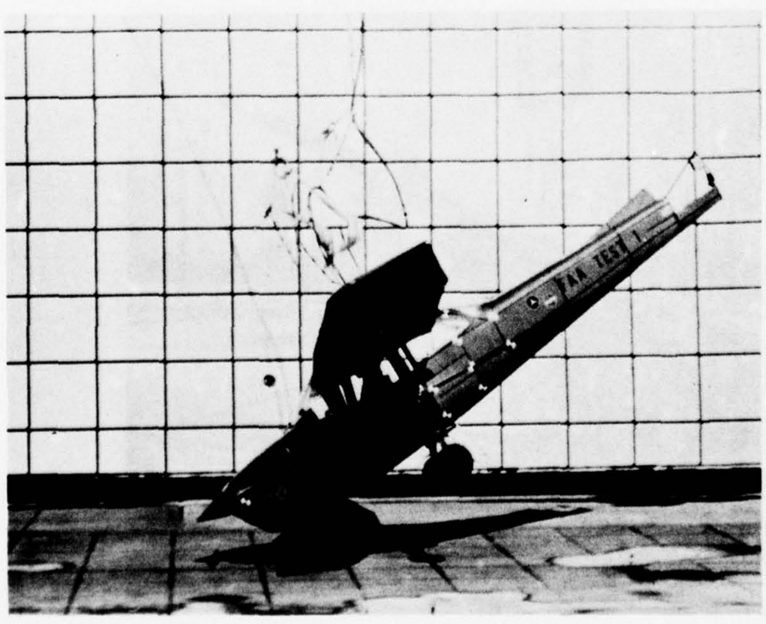


FIGURE 2-54

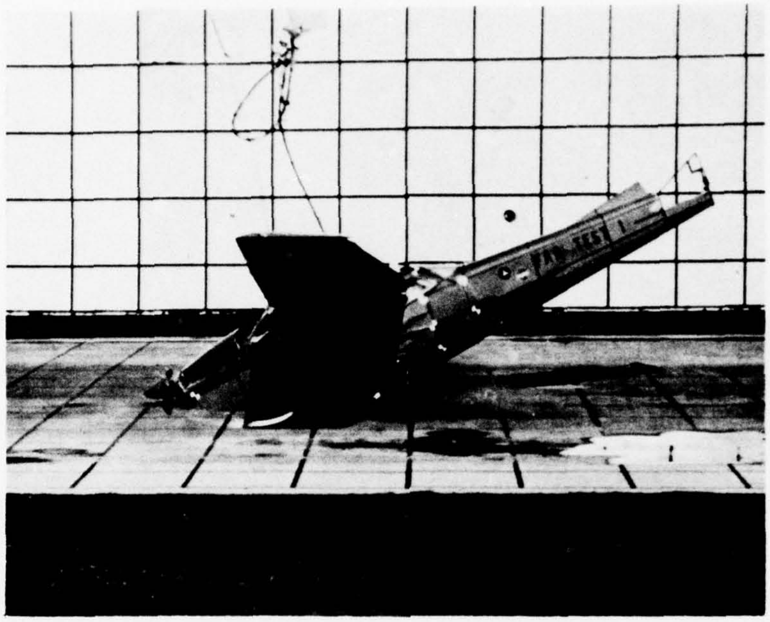


FIGURE 2-55

FIGURE 2-56

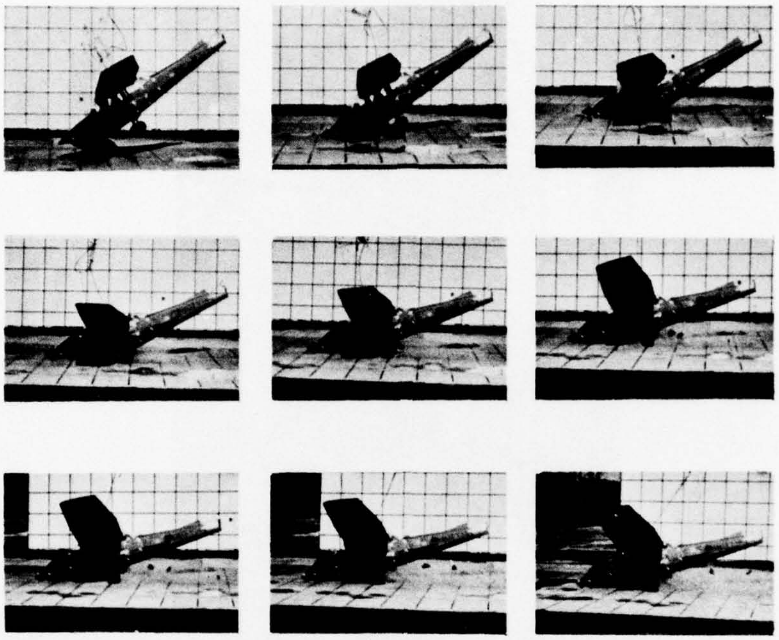


FIGURE 2-57

THREE DIMENSIONAL SEAT-OCCUPANT COMPUTER MODEL

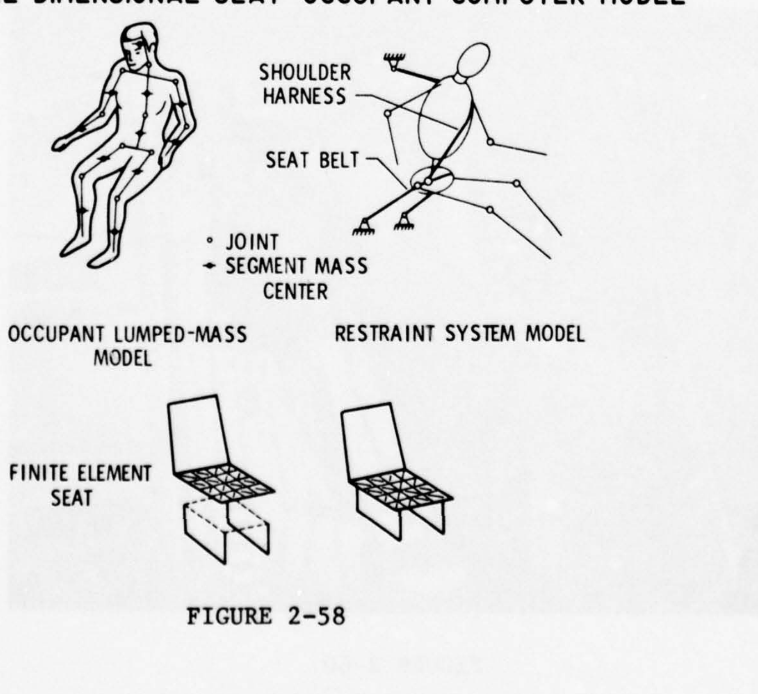


FIGURE 2-58

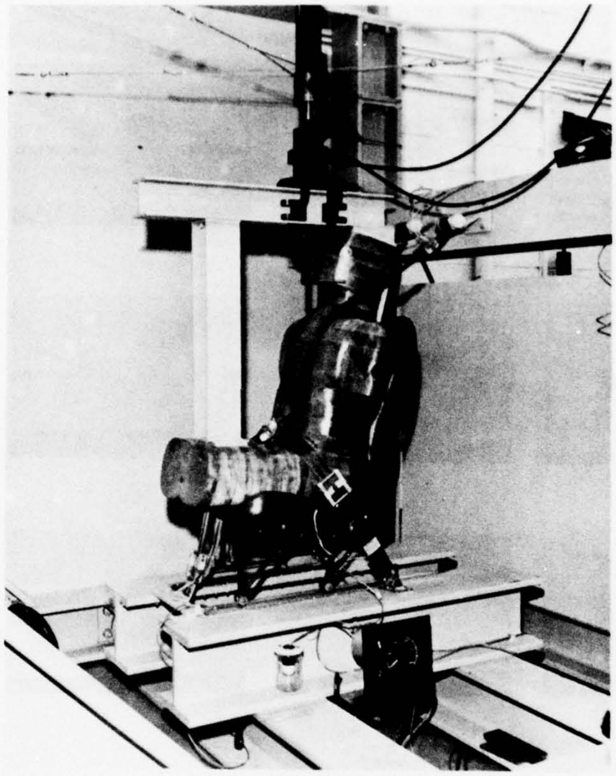


FIGURE 2-59

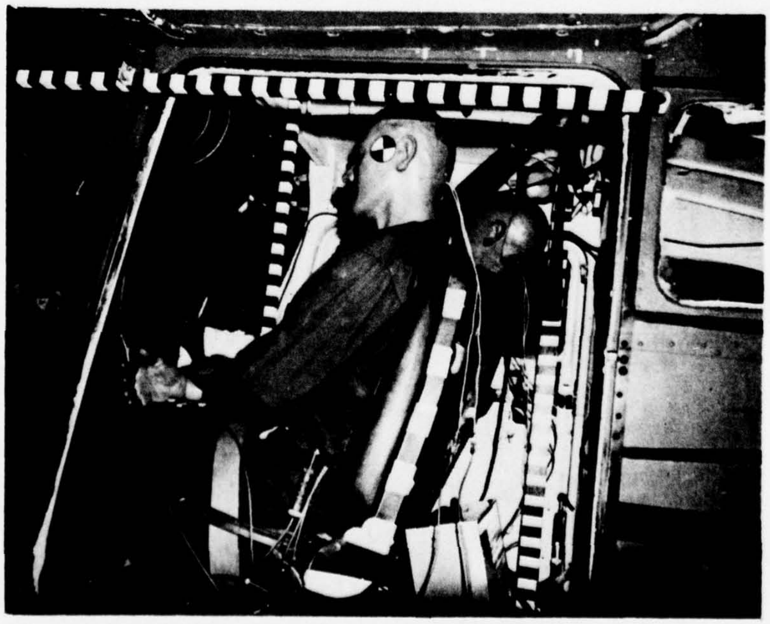


FIGURE 2-60

FIGURE 2-61

FIGURE 2-62

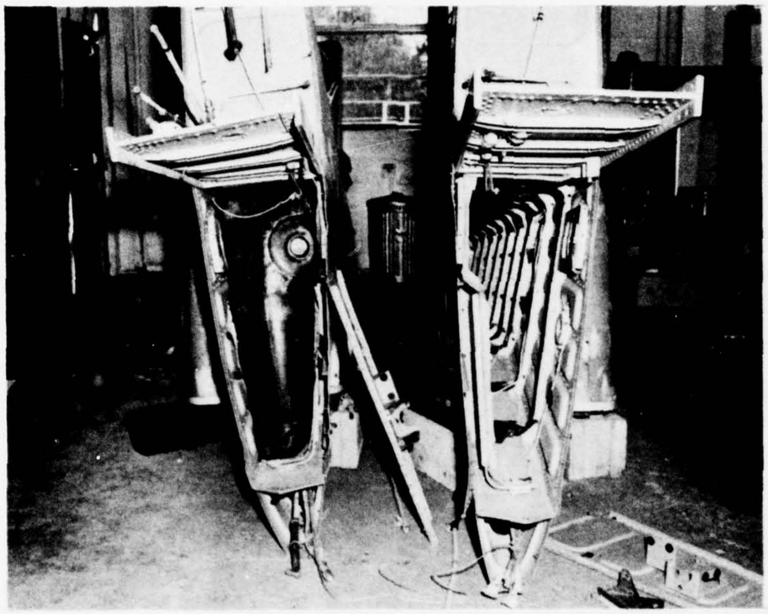


FIGURE 2-63

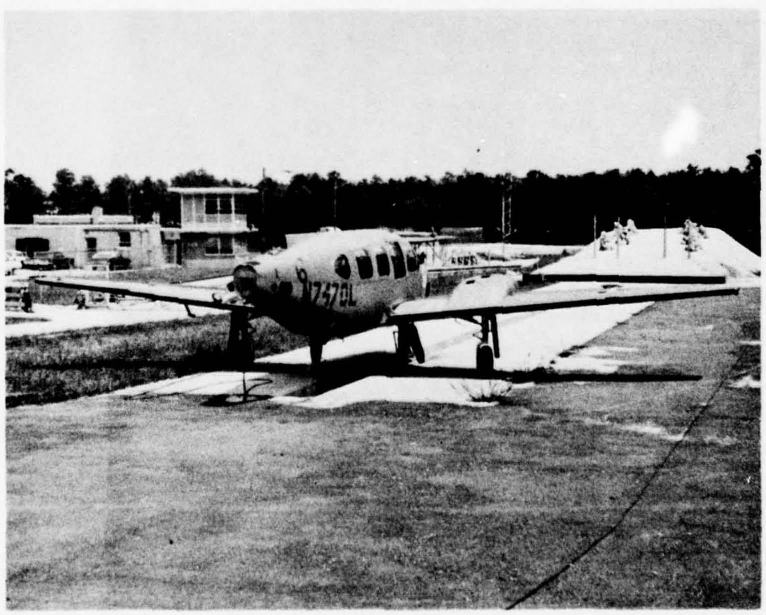


FIGURE 2-64

FIGURE 2-65

FIGURE 2-66.

A GENERAL AVIATION USER RESPONSE TO AIRCRAFT RESEARCH AND DEVELOPMENT PROGRAMS

MR. RICHARD SKULLY

Thank you, Dick. An now we save the best for last, or I know we have a fellow by the name of Stan Green, and he is going to comment on all that, and we will give him about 2 or 3 minutes to do it. Well he talks fast. And since I won't talk about him very much, I will just give his title, that's enough. They call him the Vice President and General Counselor, imagine that, of the General Aviation Manufacturing Association. This is Mr. GAMA, I mean Mr. Green. He will probably say something ugly about me.

MR. STANLEY GREEN

He's still part of that system, and the boss, so I am not going to say anything ugly about him. He's nice. He writes the regs. My job is not dropping things, but I do that occasionally. I tried, as the program was going on today, to keep some fairly good notes on the various programs of the various speakers. My purpose, of course, is to give a user response to the presentations--the manufacturers' response.

We are the guys who have to meet the regulations that are the end result of the FAA's R&D programs. We have some concerns that the FAA does not now have product liability though, unfortunately, will probably have very soon, as FAA joins us as defendants as the field of product liability law encompasses more and more people. Product liability is, frankly, a real issue with the manufacturers. It's a costly, very costly condition; it is one that, in many cases, works against innovation, because you have got to stick with the tried and true. It's one that adds to our research and development costs because, of course, you must prove that nothing bad can happen before you can take the risk of introducing something new into the market.

Now, with respect, generally, to the manufacturer's view of government R&D, we see it in a number of ways. One is a primary, NASA-type role working the basic R&D. The GAW wing series seems to me to be a classic example of iteration of the old NACA days when it developed the technology that made the United States the foremost leader of aviation in the world. We hope that this type of program will continue.

When you get into some of the work that the FAA does, however, you are in a slightly different area. We sometimes see regulations before the facts, i.e., the technology or the techniques, are developed. "Thou shalt have emission controls," or limits on the amount of emissions that your engines can produce, said EPA. And now FAA and the industry are scrambling around trying to figure out ways how to do it.

We also see regulations in another area--the government-identified "need" or public-identified "need", if you so will. And then, once the "need" has been established, we try to figure out how to meet that "need." Examples of these "needs" were discussed in the papers on the cabin interior materials program, the development program on seat belts and shoulder harnesses, and, of course, the last program presented, the crashworthiness area.

I would like to somewhat comment, in turn, on each of the programs. Recognizing that Joe Chambers is not here from NASA, I think that there are a few things that he pointed out that are worthwhile repeating. The problem of stall/spin development work and prevention is still with us after 70 years. We are still trying, today, to figure out how to keep people from killing themselves. Earlier today, in the morning program, some people suggested that perhaps we ought to reintroduce spin training for new pilots. I know it was a fun time in my flying experience. I did not look upon it with terror, because I was too young to realize that I should have been a bit scared. But it is not something that we're going to do today, from a practical point of view, if we are going to lick the problem, and that is to keep these people from killing themselves. We are going to need, as the gentlemen from Florida mentioned, some training in stall and spin detection and prevention and, more importantly, from the R&D point of view, the work that Joe is trying to do down in NASA, which the industry heartily supports.

We need spin avoidance technology as well as spin avoidance knowledge on part of the pilots. The program underway at NASA Langley with GAMA involved in the program, is, to me, an excellent way to go. But it is one that will not produce immediate answers; it will take time to prove out before we can use that knowledge in newly manufactured aircraft and in new designs of aircraft.

Now, with regard to Mr. Foster's presentation, this is an area in which the government first wrote regulations and then said, "Now do it." And it has been the responsibility of the FAA, in effect, to administer the regulations that EPA wrote. The FAA has a damn tough job, because neither they, nor NASA, nor the industry, have been able to figure out how to meet the regulations on the books, that say on January 1st, 1979, these are the maximum emission levels you can put out from turbine engines. And, at the end of that same year, 1979, EPA says that the piston engine has to meet its standards. If the engines don't meet those standards, the rules now state you don't build or you don't sell.

Well, what is the real world here? Obviously, our industry isn't going to just cease production in 1979. The programs that FAA has underway right now in the emissions area are going to salvage, which is perhaps a bad word, really save an industry from, shall we call it, ill-conceived, or to use more blunt a term, stupid government regulation. Regulation without an ability or without a conception as to how to meet it is, to me, simply stupid.

The FAA work, in conjunction with an airport study, added a new dimension to the emissions problem when you compute how much fuel our industry burns. How much possible polution can we put out? The calculations are now being confirmed by the study that Mr. Foster is getting underway, the 35-airport study

is, in effect, an expansion of the work emissions measurement that they have done at Dulles. The unfortunate part is that the timing of this study is such that it will not mesh with the time that our industry needs to convince Congress to either require the EPA to put the rules off in time a little bit, or to accept and start implementing the known technology we have today into our engines.

If we had the answers to meet EPA's regulations in hand today, it would take us between 4 to 7 years before we could produce the first engine that could be put into an aircraft, if we want to continue the same reliability that we have today (and we don't intend to degrade our reliability, and, remember, we don't have the technology in hand). I think that the FAA study of emissions at airports must be completed and presented to Congress as a reason to require the delay of the EPA's regulations, if the EPA, on its own, does not delay implementation. My notes indicate that the study is going to prove that the nonproblem of emissions from general aviation aircraft is a nonproblem. And that, I think, is our view of the EPA's regulations.

Bill Westfield's program, dealing with the piston engine emissions, is another one that's been expensive, and has been a long time in the making. We've had a number of engines under test in NAFEC, and we've had a number of engines under tests by the manufacturers. We are still continuing, from the GAMA point of view, our test program, and we've got some fairly extensive programs that we intend to propose to the EPA and FAA before the end of this year, with respect to emissions reduction. Recognizing that reductions in ambient emissions, resulting from the newly developed technology, will be unmeasurably small, the programs hopefully, will have a side benefit--a slight improvement in fuel economy or perhaps some improvement in the life of the engine, spark plugs, and some other components.

What we are looking at is an EPA-defined hazard, the general aviation aircraft emissions. The industry and the FAA, as well as other government agencies, are spending large amounts of money and time to reduce this "hazard." Everything we've done so far proves, however, that we are not a hazard. Now, whether one agency can convince another--whether the industry can convince the EPA or the Congress--that it is not worth the public's money to bother with this miniscule problem, if there is one, is another thing. We are going to, hopefully, enlist the facts gathered by FAA and NASA and present them to the Congress to see if we can't inject a little bit of common sense into this program.

I'd like to point out that much of the data the FAA collected, the data that we've collected, doesn't really prove a heck of a lot except that it is possible to reduce emissions by tinkering with the engine <u>on the test stand</u>. Our flight program work indicated that there is a correlation between the two programs, but there are enough holes in that correlation to make one wonder if its safe to fly in a modified aircraft. We had some flat spots in power, we had engine hesitation, and acceleration was nonexistant in some of the engines. Problems like this crept into the flying part of the program, when engines with the modified fuel schedules were hung on the airplane that, in some cases, we never got into the air, because the test pilots didn't have the guts to actually lift off, or they had enough common sense so that they didn't lift off.

I think one thing that we are looking at in the piston engine program, however, that we won't be seeing in the turbine program, where there is even less benefit to the public, is that the piston engine is again in the government R&D eye. The piston engine concepts that we are using today are 30 or 40 years old. As a result of the emissions regulations, the government agencies are again looking at some basic research in the piston engine design. We are going to see piston engines around for a long time. They are highly reliable, TBO's have gone up from 800 or 900 hours to 2,400 hours or more; engine failures are a rarity. They are good, they're relatively inexpensive, and we may be seeing some improvements to them as a result of the FAA and NASA programs.

Dick Nelson in his crash safety talk got into the subject of seatbelts and shoulder harnesses. This morning we heard a bit from Stan Mohler, Dr. Mohler, and one remark Stan made is worth repeating. Basically, the problem that the automobile people have is that people are not wearing the seatbelts and shoulder harnesses. We haven't had that problem in the aircraft business with respect to the seatbelt.

We've got to go a little further on the shoulder harnesses and what you can do to make them more readily usable, more easy to use, less conscious thought needed to get the pilots to use them, and the less inconvenience they cause, the greater reliability we are going to have from the product because the harnesses are going to be used. The argument that a diagonal across-the-shoulder belt may not be as good as the five-point airline-type system is not worth even thinking about if that five-point system doesn't get buckled up. The newer designs we've got in general aviation aircraft are designed to be easy to use.

The FAA has a job here--I think all of the user organizations have a job--to promote the use of these systems. There is no doubt about it that the systems work. The shoulder harness and the lap belt together are perhaps the finest safety implements we can put in the aircraft. They're inexpensive. We can do lots of other things in the way of passive systems, but you are going to pay through the nose for them, both in direct cost and indirectly in loss of payload. There is no reason to go to those systems if we can not get the people to use them, the systems available today. I don't think it's the responsibility of the government only to go out and write a regulation that says you got to wear the things. That will help, but we've got to have an industry-devoted program to convince our own to wear both the lap belt and harness.

With respect to the AS-1 data, yes, it has led to a great airplane designed for agricultural use, it has saved a heck of a lot of lives, and there are a number of things in that basic design that I know are incorporated in many general aviation personal- or business-type aircraft today. But there is one key factor that we've got to recognize in that design that doesn't work for the typical passenger-carrying airplane. The greatest safety factor that we've noticed in the crash analyses of those ag birds that do crash is the fact that you've got a tremendous energy absorber in front of the pilot. It's called the hopper. It's made to be filled with liquids or powders, which they spray but that thing is a tremendous energy absorber. The only problem is that it now makes the airplane, a single-place airplane. We don't really need that

type of aircraft in the business of carrying people and property in General Aviation. So that's a problem. The other aspect, by the way, of why that airplane is safe is that the guys who fly them wear their shoulder harnesses.

Dick Kirsch's work is part of the program we have been working with FAA since early 1971. We have also been working with the NASA-related part of it since Piper conveniently had a flood one year and drowned an awful lot of airplanes, and made them available to FAA and NASA. This program is the real way to go; it's the way to learn. However, it's time-consuming, it's expensive, and it will not give ready answers to every situation. What we learn from one crash sometimes gets dispelled in another one. But the program is moving along and the manufacturers are intimately involved in it. We participate in all of the data reviews, we meet periodically with the NASA people on it, and we are learning. It's being complemented with a lot of in-house work by the manufacturers.

Someday, and nobody can tell you when, you will see bits and pieces, and perhaps whole designs, incorporating the knowledge that we pick up from the NASA program. But it will be a cautious introduction into-the-fleet program as we must be cautious. We introduce bits and pieces, we try them out, we then broaden these bits and pieces to the whole product line and add more and more. Reliability has been rather an important part of our way of getting along.

The Army Crash Resistance Fuel Cell Program has been one that has been around a long time. The first time I got involved in that was in 1967, and we looked at the weight and all of the other complexities, and the cost, and we hesitated. Well, the weight may be coming down, and I hope the cost gets down, and I hope, from the results of the FAA's program, that we may be able to get some usable data. Now, whether it will ever be worth the cost of possibly decreasing the reliability of the fuel system is something that we are going to have to take a hard look at. No matter what happens, the customer is going to pay for this product. "Will it be worth it?" is a question that FAA is going to have to take a hard look at.

Regarding the propeller work that isn't going on, I am sort of happy to hear that. We don't need the FAA to become involved in area where the manufacturers have been really trying hard, and one of those areas is propeller development. This is a many sided program--you want to get lighter weight propellers to improve the payload of the airplane, so they become more susceptible to nicks and dings and what have you. Another two-sided example is in the work that is going on in the use of the critical airfoil for general aviation propellers. These are molded, carbon or boron filament propellers with plastic filler, are light in weight and highly efficient at the high power ranges. The boron and carbon fibers that are used are fairly tough and damage resistant. But when the propeller got more efficient, which was the objective of the program, it also got noisier, so we ran into a different problem. This work is continuing, and I don't think we need any help from the FAA at this time.

The proposed annual inspection program may be a good one to take a look at. I came from a maintenance background, and I know what it costs, and I applaud the FAA, by the way, for the 3-inch letters. That's one of the nicest things

for a guy who stood for hours, trying to mask in letters on an aircraft. The FAA is trying to help us maintain the airplanes, as users, and I think something more could be done. We need a complete look at the inspection program--the data exists, in great part, in Oklahoma City. Some work, on a sampling basis, could go on and perhaps it is something that FAA ought to undertake.

This concludes my overview of the programs. I would just like to say, in closing, that we've got really a unique industry. "Our" government body, the FAA and NASA group, our industry and our users--and I am using "industry" in its broadest sense, and by users I mean everybody who benefits from the aircraft--I think have a real good deal. We have been working together for years, and we've got a common goal. I think the programs that we have seen today are part of what we need to achieve that goal.

Thank you.

QUESTION AND ANSWER--SESSION II

AIRCRAFT SECTION

Mr. James Pyle (1st Vice President National Pilots Association) - Question

Question for Joe Chambers - NASA: Joe, is Congress being educated on this kind of thing?

Mr. Joesph Chambers - Answer

Yes, our NASA Headquarters people are being educated on this. NASA is getting the Congress informed as to NASA's efforts in this area, and the answer is yes.

Mr. Richard Long (Army R&D Command, St. Louis, Missouri) - Comment

I'd like to quibble with Stan Green, a little bit. We're on the AIAA Tech Committee on general aviation, together. But, Stan, I'd like to remind you that I think by any measure you want to use, the crashworthy fuel cell program is a roaring success. We now have a little over 90 percent of our helicopter fleet so equipped. The price has come down. The weight still stays up, because in addition to being crashworthy, they will also take a 50-calibre hit. Our newer tanks and our new development aircraft will take a 23-mm hit and that costs you weight. But, we have not had a single confirmed fatality to date for a postcrash fire. Prior to the time, 85 percent of our fatalities resulted from postcrash fires. There is one single instance where the autopsy has a little doubt - whether or not the individual died as a result of the crash injuries or fire, but I think the point remains that we still have crashes and some fatalities, but of all the crashes we've had that are considered survivable, we have not really lost a person to a postcrash fire. And I think that's worth the cost.

Thank you.

(Unidentified Individual) - Question

What is the level of effort for FAA General Aviation R&D, and how do you go about coordinating your research activities with the other government agencies?

Mr. Skully - Answer

In general aviation and total for the FAA, people in contract, I would say runs around $700,000, would be the number, slightly less than a million. In the coordination, generally it is pretty good; we have NASA exposure, military exposure I don't think there is any duplication to our knowledge; I think it's a fairly well coordinated effort and we steal ideas from anybody, like the Army.

Mr. Chet Rembleske (Chief Aircraft Engineering, Beech Aircraft) - Question

I would like to ask Chuck whether he has a timetable on when the program for sampling these airports is going to be completed?

Mr. Chuck Foster - Answer

Actually, the study I've mentioned is not going to be a sampling program. It's going to be a modeling program in view of the data that we've gathered out at Dulles. We have taken the models that were used previously; we've calibrated these models where we feel we can do that analytically rather than having to go out and sample these, which will enable us to do it mush more rapidly.

Mr. James Pyle - Comment

Let's see, I'll try to make it real quick, but there's one area that hasn't come up today and I am not sure whether its susceptible to R&D or not, but it's to you, Chuck, so I warned you I would. It's a question of noise in the general aviation operational environment. I think most of us know it's one of the single most important factors in inhibiting the construction of new general aviation airports. Everybody wants them, just as long as it's not in my backyard. I think it involves three things: the manufacturer; the training program to make pilots conscious that there is a noise problem; and the operational procedures that they should follow; and lastly, the operator, setting up noise abatement procedures and hopefully the pilots will follow. We as a general aviation community have one hell of a responsibility if we want to keep on operating the way we have been up to this point. Chuck, have you had any thoughts on that?

Mr. Charles Foster - Answer

Well, first I'd like to say that I think the record of general aviation in this area speaks well for itself. I think GAMA and some of the early efforts they had of developing their jets, developing various types of noise abatement departure and approach procedures, and disseminating that information to the users of jet aircraft has been very effective. I think as far as the training is concerned, Dick Skully and his people had over the last 12 months, now completed meetings and conferences bringing in all people involved to make sure that the instructors will be able to incorporate in their instruction, information relative to the noise, we've been talking about, as we've been talking in our shop. Also we are looking at the possibility of trying to incorporate some way, maybe in the Flight Manuals or the Ops Manuals that are now coming out, the new ones particularly, to give the operator some idea of just what it means, whether he's using 2,700 rpm vs. 2,500 or 2,600, as far as the noise on the ground is concerned. Also, the airport operators, I think, particularly the smaller operators, are realizing that it's very difficult to have these flights going off (on Sunday morning) at 6 o'clock and flying over residential sections, churches, etc. And I think, generally speaking, that all three elements, both the manufacturer and the noise level, as far as the aircraft are concerned,

training and awareness on the part of the pilots as well as the airport operators, and the procedures that are being established, all are moving in the right direction. I think that you're now starting to see people who are reducing their max rpm. For example, Cessna's new airplane, the new 152, there's quite a writeup in one of the magazines that they've dropped it a couple of hundred rpm's, which really brings noise down, and just awareness.

Fortunately, a lot of the things that deal with the noise are practical things. If you pull the power back you're going to reduce the noise. On takeoff, you don't want to leave takeoff power on all day: you don't want to burn up any more fuel than you have to.

Generally speaking, I think that we're still going to have problems in the places where we have a lot of the old airplanes that are still around. I do not think that the problems from the general aviation of the future are going to be at all from the airplanes that are coming off the production line today or with the fan engines that are coming out in our jets now. I think that the major complaints that we're getting from the airport people are not from the new airplanes, they're from the fact that we've got some 150,000 airplanes that are still flying around in this country that are categorized as general aviation, and some of those, such as old World War II converted airplanes, and others that had props that ran at high rpm's, etc., a lot of those airplanes make the noise, and that is really what the complaints are about, "noise". Really, it's kind of like the truck situation on a highway, you could have 3,000 or 4,000 cars an hour driving down a highway, and you put 15 or 20 big trucks on there without a muffler, your highway noise problem is the trucks. Around the airport, I think that part of the solution of this is going to be that the airport proprietors are going to have to be concerned about what types of airplanes operate there, and if they have some old noisy airplanes that are operating around there, SA-16, BT-13, for some of those airplanes the noise is excessive. They're probably just going to make sure they don't fly them on a Sunday morning, and they don't fly them at times they're going to disturb the people. Generally speaking, I think the general aviation record in this area is very good, Jimmy.

Mr. Bernard Karsh (University of Illinois) - Question

It occurs to me that there may be yet another area of research and development which has not been explored. The question of structural design safety, and engine design safety, etc., is certainly essential in general aviation, but so, it seems to me, is the question of the training of people who are to maintain all these complex structures, or otherwise simple structures, in engines. The present mechanisms for doing this, procedures for doing this, and processes for doing this are largely carryovers, it seems to me, from the days of apprentice/master/servant relationships of feudal times: 1900 hours of training and you're somehow certified to fix helicopter rotor blades even though you've never seen one in school anywhere. Goodness knows that the problems of maintaining avionic equipment in aircraft is becoming increasingly impossible, and I suggest that as the future goes on, the problems of maintaining engines and structures are going to be increasingly impossible, largely due to the archaic ways in which

we train mechanics, and continually demand upgrading of their skills. Is anyone in FAA addressing themselves to these questions? The questions of relevance, present training requirements, present training standards, and present training techniques for the maintenance of aircraft and related equipment?

Mr. Richard P. Skully - Answer

I'd like to say we think we are continuously but probably not to the extent that you'd like it done. I have some representatives here that made note of that. Is there another question? What I'd like to do, since I am the last man on today's program here, is to take advantage of the platform and summarize. And since Stan Green summarized all the FAA people, it leaves me with the opportunity to summarize Stan Green. At times, Stan speaks clearly, but you really have to know him to know what he said. Now, what he really was telling you folks, and this gives me a real in, he's really saying that organizations such as his--and if we're really talking of the general aviation clout, the organizations that represent many of the operators--he's really saying that the EPA standards on emissions have been ridiculous, very costly to you, the operators, the purchasers of aircraft, the builders of aircraft, and that you should have done something about it. And I'll go on further in elaborating on what Stan said; he's really saying that the delay in wiping out the standards in piston engines, if something isn't done, then the development for new engines is going to wait until the deadlines come to pass. And, it's just going to cost more, it's just slowing up any progress, Stan thinks, relative to the development of aviation. He also suggested that he didn't want FAA to help him on developing better propellers. I think I heard that; now I don't want to "out quote" Stan Green. I'd just like to say, in concluding that one, I am impressed with the turnout of the people here not just the numbers but the organizations that they represent, and it's kind of delightful to run into an old colleague of mine, General Campbell Jackson, who is representing the State of New Jersey. I am very happy to have you here. And of course, everybody knows Jim Pyle here. And I will say this as an apology to the answer on the amount of money being funded for general aviation's safety, I think it STINKS. I think it's a crime that we're spending, obviously, big dollars on emissions for a 170,000 aircraft when Tysons Corner's in Virginia automobiles would give off a hell of a lot more emissions in any afternoon than these things would in a week. But, that's what we're doing, and it just isn't fair. Okay, thank you.

SESSION III

WEATHER AND FSS

Mr. Lawrence L. Langweil, Chief
Aircraft and Airport Safety Division
FAA National Aviation Facilities
Experimental Center

CHAIRMAN

Mr. Henry G. Tinsley, Chief
Wind Shear WVAS Branch,
Approach Landing Division
FAA Systems Research and
Development Service

Mr. Joseph F. Sowar, Chief
Aviation Weather Systems Branch,
Airports Division of FAA Systems
Research and Development Service

Mr. Robert J. Roche, Assistant Chief,
Flight Information Services,
Airport Division
FAA Systems Research and
Development Service

Mr. Victor J. Kayne
Senior Vice President for Policy and
Technical Planning of the Aircraft
Owners and Pilots Association

WEATHER AND FLIGHT SERVICE STATIONS

MR. L. L. LANGWEIL

Good morning ladies and gentlemen:

The three subjects we are going to discuss are probably the most important areas for General Aviation. The primary source of information and services to General Aviation is, of course, the flight service station. We have 292 flight service stations at various locations throughout the country. These have been located and installed in an evolutionary manner starting in the 1920's. Their locations were dictated by traffic patterns that have long since changed. Flight service stations, as they are operated today, are extremely labor intensive with over 75 percent of the cost of operations going to pay labor costs. As we project the growth of General Aviation into the 1990's, and with it the resultant demand for increased services, it becomes evident that the flight service station operation as we know it today cannot accommodate this increased demand. Therefore, the subject of flight service station modernization is one of major interest and concern for the general aviation user.

The second major topic involves weather and weather-related phenomena such as wind shear. Weather is a significant causal factor in all accidents involving both civil and General Aviation. We will discuss the FAA's program involving new methods of improving the collection and dissemination of up-to-date weather information.

The third topic has to do with wake vortices. Many people, when they first think of wake vortices, think of a problem having to do with civil aviation, since it is primarily large jet transports that generate wake vortices. Now, this is certainly true. However, if one looks at the accident and incident statistics, one will find over 90 percent of accidents which occur as a result of wake turbulence occur to the general aviation public. And certainly, as a result of this, General Aviation must be concerned with this phenomenon.

WIND SHEAR/WAKE VORTEX IMPLICATIONS FOR GENERAL AVIATION OPERATIONS

MR. L. L. LANGWEIL

With this brief introduction, I think we are ready to start with our first subject which covers the work that the FAA has been doing in wind shear and wake vortex. We have as our first speaker, Guice Tinsley. Mr. Tinsley has recently retired from the Air Force where he had been a pilot, flown many different aircraft varying in size from light, general aviation type aircraft to large transports. As part of his Air Force work he had been assigned to

the FAA, done work in all-weather landing systems lighting, CAT III ILS development, and cockpit displays. Approximately a year ago, he was named as a program manager for wind shear and wake vortex studies. If I had to choose one individual in the FAA to best describe the FAA's wake vortex and wind shear program, Mr. Tinsley is certainly the man I would select.

MR. H. GUICE TINSLEY

GENERAL

The FAA is conducting a comprehensive research and development program to deal with the aviation hazard of low-level wind shear, figure 3-1. Several parts of the FAA Wind Shear Program are producing benefits for General Aviation.

DEFINITION

Sharp gradients in the wind field, referred to as wind shears, encountered by aircraft on takeoff or final approach, have caused serious accidents. Wind shear is any change in windspeed and/or direction through any thin layer of the atmosphere, figure 3-2. It can be gradual, or it can be abrupt. Low-level wind shear is defined as that shear occurring in the layer of the atmosphere between the surface and 1,500 feet above ground level.

THE PROBLEM

Severe wind shear conditions occurring at low altitudes in the terminal area are hazardous to aircraft during both approach and departure. Any wind shear produces an immediate dynamic effect on the aircraft. This dynamic effect is particularly noticeable during an approach, because the airplane is being flown at relatively low airspeeds along a precise three-dimensional path with relatively small operational tolerances, figure 3-3. Airflow over the wing is effectively changed without either thrust or attitude change. In its very basic form, there are two shear conditions to consider. In one, the effective airflow over the wing is increased (headwind), and it is decreased in the other (tailwind).

If an aircraft is on glidepath with a stabilized approach, this increased effective airflow over the wing will cause an airspeed increase, and the aircraft will initially tend to go above glidepath. The reverse is true when encountering a condition of decreased headwind or increasing tailwind; then, the effective airflow over the wing decreases.

TYPES OF WIND SHEAR

There are three basic types of wind shear: orographic, topographic and atmospheric. Orographic wind shear is that caused by mountainous terrain, figure 3-4. Familiar examples of this type of shear are mountain wave activity and the downdrafts found on the lee side of mountains. Topographic wind shear is that caused by local terrain features and obstructions. Familiar examples are the

wind shifts and gusty conditions found on the lee side of large buildings and treelines. Atmospheric wind shear is the least understood, and most unpredictable. By its very nature, it is insidious and presents the greatest hazard to aviation.

MAJOR CAUSES OF WIND SHEAR---Gust Front, Frontal, Low-Level Jets, figure 3-5.

A. Inversion. The low-level jet condition is found where a low-level temperature inversion forms near the surface with a warmer, low-level wind of considerable magnitude immediately on top of the inversion, figure 3-6. This situation typically occurs after midnight in desert areas.

B. Frontal Passage. Other mechanisms capable of causing strong wind shears in frontal zones. These zones are routinely identified by conventional meteorological analysis. However, identification of the shear associated with them is much more difficult.

C. Thunderstorm Gust Fronts. Gust Fronts are normally formed from mature, severe thunderstorms and, when located in the vicinity of airports, can be extremely hazardous to air traffic. A zone of maximum hazard precedes the radar echo and is not identified by current airport surveillance radars or adequately detected by today's airport weather sensors, figure 3-7. Strong gust fronts can appear as far as 30 kilometers away from the parent thunderstorm.

WIND SHEAR PROGRAMS

Several parts of the Wind Shear Program will be of interest to you, figure 3-8.

Accident/Incident Analysis
Hazard Definition
Improved Wind Shear Prediction
Language Development
Manned Flight Simulations

WIND SHEAR ACCIDENT/INCIDENT ANALYSIS

From 1964 through 1975, the National Transportation Safety Board (NTSB) investigated or acquired data on nearly 60,000 aircraft accidents. The NTSB data bank for these accidents was searched for key wind shear indicators. A review of the accident briefs was performed and finally inspection of the NTSB accident docket, figure 3-9. This investigation revealed that wind shear could have been a factor in 20 accidents involving small (less than 12,500 pounds) multiengine aircraft. At this time, over 2,000 accident briefs must be reviewed before a determination can be made for small single-engine aircraft.

WIND SHEAR HAZARD DEFINITION

The general objective of the hazard definition program is to define the wind shear hazard potential in terms of altitude, airspeed, severity of shear, aircraft type (or category), configuration, and gross weight and to refine

the capability to express the hazard in comprehensive terms that are meaningful and useful to pilots, figure 3-10. Fast time computer simulation studies are conducted to determine aircraft performance characteristics under various wind shear encounter profiles, to investigate the factors involved in wind shear accidents/incidents and their relationship to the severity of the hazard, and to evaluate procedures designed to increase operational tolerance to wind shear---one of which is recognition and avoidance.

WIND SHEAR PREDICTION

Prime wind shear prediction techniques are already being used by air carrier meteorologists with success, and it was decided to further investigate those as well as others. The technique tested uses a frontal speed versus temperature difference across the frontal zone to determine if significant low-level wind shear should be forecast, figure 3-11.

Since occurrence of frontal wind shear reaches its maximum during the December-March period, it was jointly agreed by NWS/FAA that a 6-month test of techniques being evaluated would be made from November 1976 to April 1977. The test included seven East Coast airports, located at New York, Philadelphia and Washington, D.C. Forecasts from NWS were issued to the FAA's Air Traffic Control System's Command Center in Washington, D.C., where they were relayed to the air traffic control facilities affected. Telephone hotlines were used to relay the wind shear advisories. The advisories were of very short duration, not more than several hours, and were further disseminated to pilots via the FAA's Automatic Terminal Information Service. The advisories were also available to pilots through the appropriate enroute air traffic control centers.

Verification of the wind shear forecasts has been through pilot reports, data collected from meteorologically instrumented FAA aircraft, and the acoustic wind shear detection test system located at Dulles Airport. Successful in forecasting warm fronts, testing will continue this winter to improve cold front forecast technique.

WIND SHEAR LANGUAGE DEVELOPMENT

At present there are misinterpretations of the technical terminology used by the aviation weather community to describe wind shear, figure 3-12. For example, horizontal wind which changes as a function of altitude is a "vertical" wind shear, and some call it a "horizontal" wind shear. Pilots and controllers require clearly understandable terms for a shear which causes a decrease in the aircraft's airspeed as opposed to a shear which causes an increase in airspeed.

WIND SHEAR MANNED SIMULATIONS

A series of flight simulation experiments is being conducted to identify and refine the most effective pilot-aiding concepts for wind shear, figure 3-13. The first simulation effort was designed to provide an early determination of

the potential operational effectiveness of candidate systems and techniques that could be used to guide in-depth studies and system refinement. The results of these experiments indicate that groundspeed/airspeed comparison ranked as the best aiding concept.

Additional manned simulation experiments will be conducted to support flight test programs and to determine the feasibility/necessity of applying selected aiding concepts to general aviation aircraft. The pilot-aiding concepts to be evaluated will be those which are most cost-effective and usable. Experiments will include the use of:

- Pilot Advisories
- Ground/Airspeed Comparisons---Requires groundspeed in cockpit
- VASI
- Various Types and Severity of Shears.

WIND SHEAR CONSIDERATIONS FOR GENERAL AVIATION

Several important considerations for General Aviation concerning wind shear have emerged from studies completed and experience accumulated to date, figure 3-14.

Thunderstorms/Gust Fronts. Avoid thunderstorms. Do not takeoff or land when a thunderstorm is in close proximity to the airport. Know that a hazardous gust front can appear, in clear air, many miles from the parent thunderstorm.

Topography. Know the topography around the airport and the wind direction and speed. Avoid landing on the lee side and in close proximity to large obstructions on windy days.

Short Field Procedures. Do not use short field procedures during known or suspected wind shear conditions. An aircraft is most susceptible to wind shear when operating at low airspeeds.

Airspeed Control. Carry extra airspeed on final during known or suspected wind shear conditions. If field length does not permit extra airspeed, land elsewhere. Do not take off into known or suspected wind shear conditions.

WAKE VORTEX ALLEVIATION

Experimental research is being conducted jointly by the FAA and the National Aeronautics and Space Administration (NASA) in the area of wake vortex alleviation through aerodynamic methods, figure 3-15. Aerodynamic alleviation is the general term describing modifications made to the airframe or airfoil which will favorably alter the vortex structure, figure 3-16. The goal of aerodynamic minimization is to decrease the allowable longitudinal spacing between aircraft by modifying the vortex structure in such a way that if a vortex encounter does occur, the resulting upset will not exceed the control authority of the following aircraft.

Aerodynamic alleviation is achieved by modification of the spanwise wing loading or by the generation of turbulence behind the penetrating aircraft.

NOTE:

At the request of the session chairman, Mr. Larry Langweil, the following descriptions of related areas are provided.

VORTEX ADVISORY SYSTEM

The Transportation Systems Center (TSC), under the sponsorship of the Systems Research and Development Service of the Federal Aviation Administration, is approaching the vortex problem by developing systems which use vortex tracking sensors and/or meteorological sensors to advise the air traffic controller as to whether or not a hazardous condition exists or is forecast.

Analysis of extensive data on vortex behavior as a function of meteorological conditions taken by TSC during a 3-year test program at Stapleton, John F. Kennedy, and Heathrow International Airports have indicated that there are wind conditions which predictably remove vortices from the approach corridor. It has been determined that a wind rose criterion can be used operationally, and that when the criterion is met, the separations can be uniformly reduced to 3 nautical miles for all aircraft types. This contrasts with the current requirement for 3, 4, 5 and 6 mile separations.

This result permits very simple and economical implementaion of a Vortex Advisory System (VAS) which compares measured wind magnitude and direction with the wind rose criterion. The comparison indicates on a simple display when separations can be safety reduced to 3 nautical miles for all aircraft.

The VAS meteorological network consists of seven 50-foot towers located to measure wind parameters at each of the operating corridors.

Data are transmitted from the meteorological towers to the centrally located processor. A multiplexer successively samples the sensor outputs and converts these to a parallel digital data word which in turn is serialized and transmitted over standard existing FAA lines to a central facility where receivers reconvert the data to a parallel format for input to a microprocessor.

The sensor outputs are sampled at two samples per second with 2-minute running average maintained on each sensor. The averaged meteorological data from the runway in use is then compared to the meteorological VAS algorithm and the vortex condition determined. Long-term sampling and hysteresis are used to prevent frequent and erroneous changes in the indicated vortex condition.

The system interfaces with the controllers through the VAS display. In operation, the controller designates either an arrival (A) or departure (D) runway and its heading. The display thereafter accepts data with the corresponding label output on the data bus by the VAS processor. The display repeats the runway designation, and indicates wind magnitude, direction, gust, and the RED (3/4/5) or GREEN (3/3/3) vortex condition.

SURFACE WIND MONITORING SYSTEM (SWIMS) (Low-Level Horizontal Wind Shear Alert System)

What: Design and install a system of sensors, processors and displays at 6-8 airports to determine the effectiveness of an array of anemometers in the detection of horizontal wind shear. The output of anemometers located around the periphery of the airport shall be automatically and continuously compared with the operational aviation wind (center field) and the tower operation alerted when vector differences exceed an established threshold. Controller will then alert pilots of impending hazard.

Who: The system has been designed and installed by NAFEC with support from the appropriate regions. Due to very tight schedule, off-the-shelf hardware was procured and assembled to meet system requirements.

Where: SWIMS has been installed at six airports

Houston Intercontinental
Tampa International
The W. B. Hartsfield, Atlanta International Airport
JFK, New York
Stapleton, Denver
Will Rogers, Oklahoma City

Recently, Logan Airport at Boston has been added to the list and will be done late 1977.

When: The program was initiated in January 1977 with the first installation completed at Tampa on May 27, 1977. All other airports will be completed by early August 1977.

Why: Detection of large differences in surface winds around the airport is a relatively simple task which provides a positive indication of a horizontal wind shear within the airport terminal area. Knowledge of this fact could substantially reduce the potential for wind shear encounter, thereby improving the safety of flight.

FIGURE 3-1

W I N D   S H E A R

- D E F I N I T I O N

WIND SHEAR IS ANY CHANGE IN WIND SPEED AND/OR DIRECTION THROUGH ANY THIN LAYER OF THE ATMOSPHERE

GRADUAL IS OF THE MAGNITUDE 4 KNOTS/100 FEET

ABRUPT IS OF THE MAGNITUDE 10 KNOTS/100 FEET

FIGURE 3-2

WIND SHEAR

PROBLEM:

AIRCRAFT ENCOUNTERING SEVERE WIND SHEARS DURING FINAL APPROACH OR DEPARTURE MAY NOT HAVE SUFFICIENT CAPABILITY OR TIME TO OVERCOME THE EFFECTS OF THE CHANGED WIND CONDITIONS.

FIGURE 3-3

TYPES OF WIND SHEAR

- OROGRAPHIC
- TOPOGRAPHIC
- ATMOSPHERIC

FIGURE 3-4

MAJOR CAUSES OF WIND SHEAR

- THUNDERSTORM GUST FRONTS
- FRONTAL ZONES
- LOW-LEVEL JETS

FIGURE 3-5

LOW-LEVEL JET CONDITION

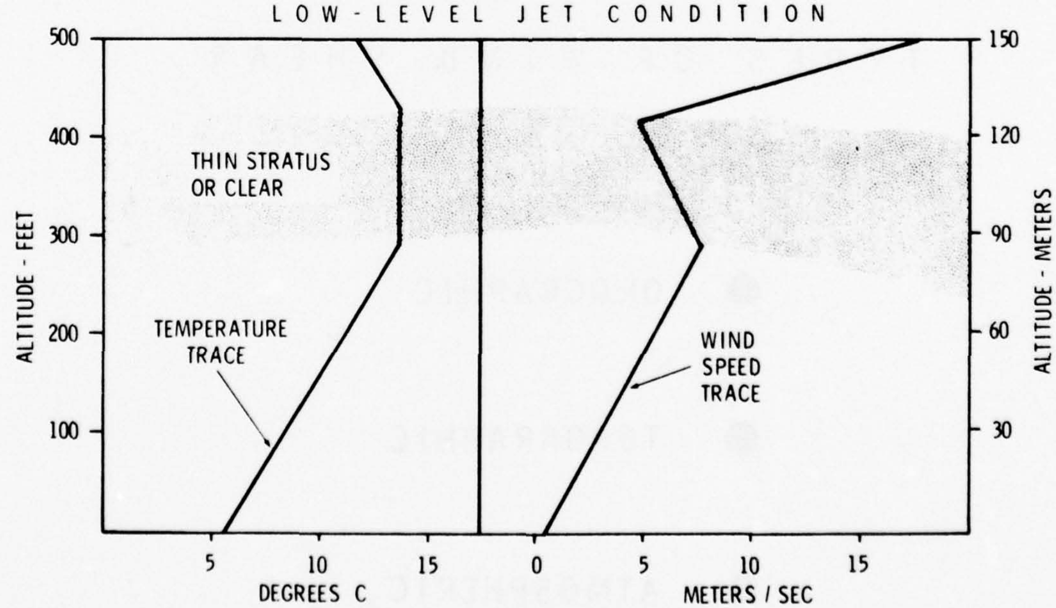


FIGURE 3-6

VERTICAL CROSS SECTION
OF A THUNDERSTORM

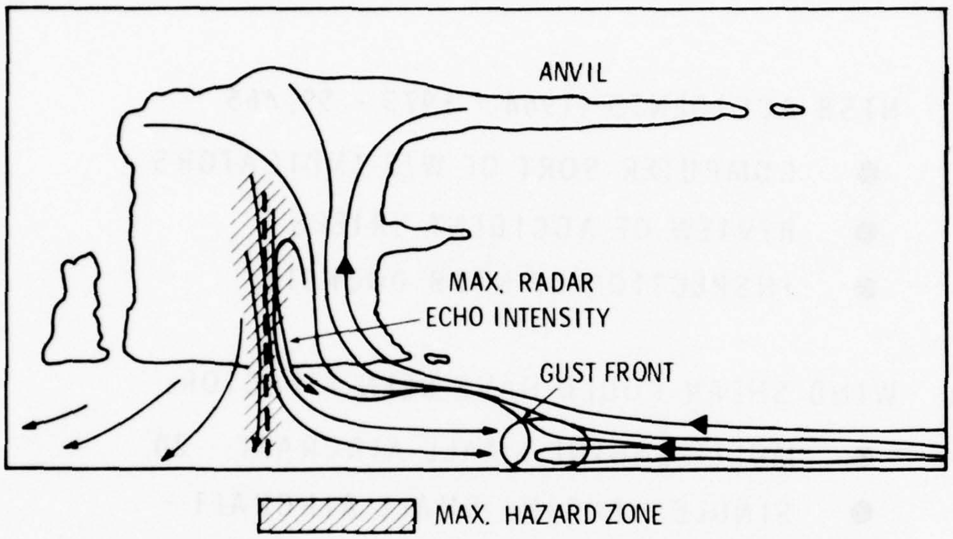


FIGURE 3-7

WIND SHEAR PROGRAMS RELATED TO GENERAL AVIATION

- ACCIDENT/INCIDENT ANALYSIS
- HAZARD DEFINITION
- WIND SHEAR PREDICTION
- LANGUAGE DEVELOPMENT
- MANNED FLIGHT SIMULATIONS

FIGURE 3-8

WIND SHEAR ACCIDENT/INCIDENT ANALYSIS

- NTSB ACCIDENTS (1964 - 1975 - 59,465
  - COMPUTER SORT OF W/S INDICATORS
  - REVIEW OF ACCIDENT BRIEFS
  - INSPECTION OF NTSB DOCKETS
- WIND SHEAR COULD HAVE BEEN A FACTOR:
  - MULTI-ENGINE SMALL AIRCRAFT - 20
  - SINGLE - ENGINE SMALL AIRCRAFT -

FIGURE 3-9

WIND SHEAR HAZARD DEFINITION

- COMPUTER SIMULATIONS OF A/C PERFORMANCE
  - •VARIOUS TYPES/CATEGORIES OF A/C
  - •VARIOUS WIND SHEAR PROFILES
- HAZARD DEFINED IN TERMS OF
  - •A/C TYPE / CATEGORY
  - •ALTITUDE
  - •AIRSPEED
  - •SEVERITY OF SHEAR
- LIMITED AVAILABILITY OF A/C MODELS

FIGURE 3-10

WIND-SHEAR PREDICTION NWS

- TEST OF FRONTAL SPEED/△ TEMP TECHNIQUE
  - SEVEN EAST-COAST TERMINALS (JFK, LGA, EWR, DCA, IAD, PHL & ACY)
  - NOV 76 - APR 77
- EXPAND NATIONWIDE IF SUCCESSFUL
- LONGER TERM DEVELOPMENTS
  - SHEAR INTENSITIES
  - THUNDERSTORM GUST FRONTS

FIGURE 3-11

WIND SHEAR LANGUAGE DEVELOPMENT

- STANDARDIZED DEFINITIONS/TERMINOLOGY
- STANDARDIZED FORMATS
  - WEATHER FORECASTS
  - ADVISORIES
  - PIREPS
- LANGUAGE TESTED AND REFINED IN MANNED SIMULATIONS

FIGURE 3-12

WIND SHEAR MANNED SIMULATIONS
FOR GENERAL AVIATION

- TWIN-ENGINE EXECUTIVE AIRCRAFT
- SINGLE-ENGINE AIRCRAFT
- EXPERIMENTS
  - PILOT ADVISORIES
  - GROUNDSPEED/AIRSPEED
  - VASI
  - VARIOUS SHEARS

FIGURE 3-13

WIND SHEAR CONSIDERATIONS
FOR GENERAL AVIATION

- THUNDERSTORMS/GUST FRONTS
- TOPOGRAPHY
- SHORT FIELD PROCEDURES
- AIRSPEED CONTROL

FIGURE 3-14

RELATIVE EFFECTIVENESS OF VORTEX MINIMUMIZATION CONCEPTS

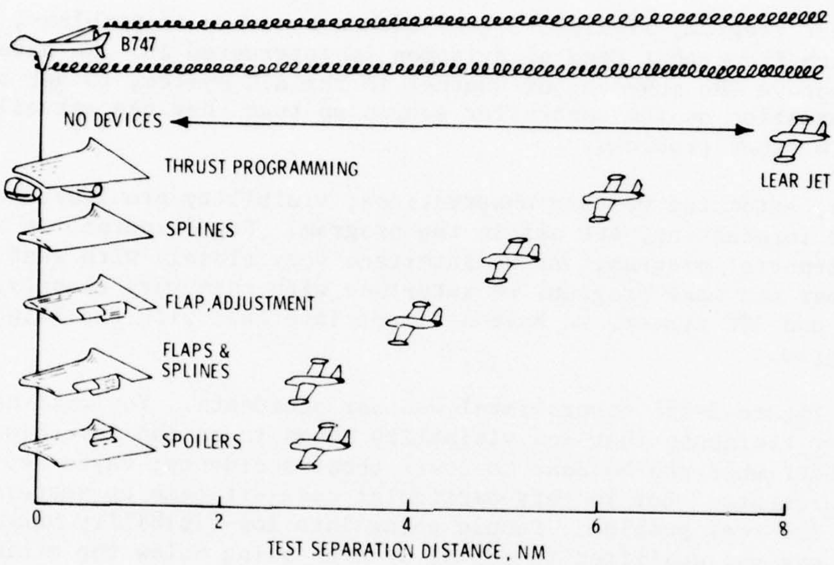


FIGURE 3-15

747 WIND TUNNEL TEST MODEL

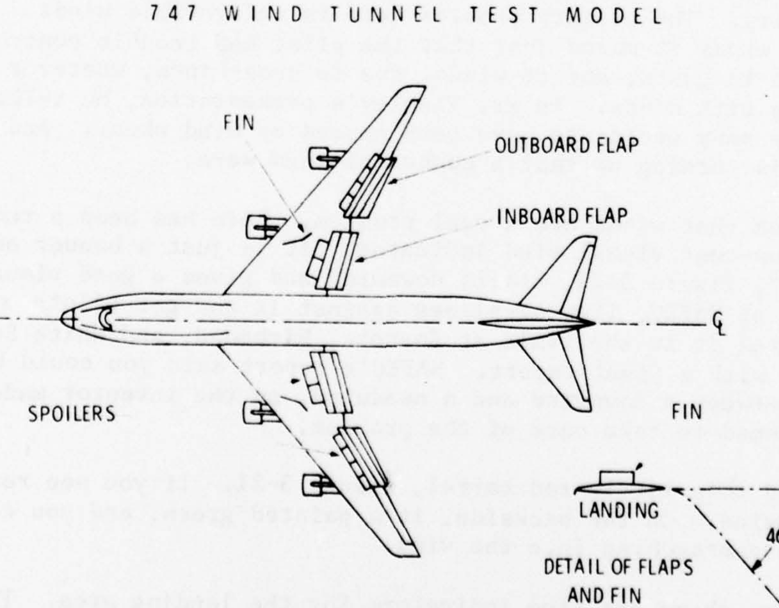


FIGURE 3-16

IMPROVED WEATHER DATA FOR GENERAL AVIATION OPERATIONS

MR. JOSEPH SOWAR

In the weather program, figure 3-17, we tackle a number of problems, and most of them deal with items that General Aviation is interested in. We have a major effort to improve the movement of weather in the ATC system, to get better weather information on the controller scopes so that they can actually help pilots with weather problems.

Other things, automated weather observations, visibility problems, severe weather, and forecasting, are all in the program. Fog dispersal is not. It is in our airports' program, and we interface very closely with that one. On the wind shear and wake program, we interface with them very closely, and through the weather and ATC system, we have a direct interface with the Flight Service Station program.

This chart, figure 3-18, covers fatal weather accidents. You will notice in fatal weather accidents that low visibility seems to be the key thing, so you begin to wonder what can be done to lower those accidents; maybe better visibility measurements. But in this particular case--it came up yesterday--judgment seems to be the real problem. People going into low-visibility conditions when they really are not qualified to do it, or even going below the minimums established---that's what is causing accidents.

When we get into nonfatal accidents, figure 3-19, there is a shift from the low visibility. The primary problem here is unfavorable winds. And by unfavorable winds it means just that the pilot had trouble controlling the aircraft due to gusts, due to winds, due to crosswinds, whatever you might have dealing with winds. In Mr. Tinsley's presentation, he talked about looking into how many accidents have been caused by wind shear. And as you might expect, it is turning up that a number of them were.

With the idea that winds are a real problem, there has been a recent invention of a very low-cost visual wind indicator. It is just a banner on a pole that swivels 360°, figure 3-20, trails downwind and gives a good visual cue. We tested this at NAFEC, flew airplanes against it and got pilots reactions. We also tested it in the field at Roanoke, Richmond, and White Sulphur Springs, and came up with a final report. NAFEC's report said you could have an ambiguity between a downwind and a headwind, so the inventor made a change, and this has seemed to take care of the problem.

He has added this little red barrel, figure 3-21. If you see red on the barrel, that's downwind. On the backside, it's painted green, and you can tell then that you're approaching into the wind.

We think that these are fine indicators for the landing area. The state of Virginia Aeronautics Division is buying these for many of the airports in

Virginia. This one with the barrel has been put in at Glen L. Martin, north of Baltimore. Pilot reports from there have reported no ambiguity, and our final report says that this is a good thing to install.

The altimeter setting indicator for years and years has been a little needle, figure 3-22, very difficult to read and sometimes leading to a misreading of altimeter setting. We looked at this problem and decided we needed a digital readout for the controllers to see them.

Such a digital readout has been developed, figure 3-23. The main unit, of course, is not in the tower. Up in the tower is just the readout. You will note that the readout 29.89 is very visible. This is a solid state system with digital output that can be transmitted on a telephone line from the main unit, so that gave us another idea.

We ran a test here at NAFEC, figure 3-24. We put the main unit at Cape May and have our readout in Atlantic City. The idea is this: even if the altimeter settings at Atlantic City and Cape May are the same, the fact that a pilot coming in and requesting altimeter setting got it from a measurement made at Atlantic City requires a penalty in the minimum approach altitude, since the altimeter setting was taken 30 miles away. The minimum for approach at Cape May would be 540 feet. With the altimeter actually taken at Cape May and transmitted back to Atlantic City so that the controller is reporting the actual altimeter setting, you can lower the minimum to 415 feet.

Our final report is not yet complete, but this particular digital altimeter setting is very stable. It has been holding stable for 3 to 6 months without recalibration, so I think we have a real use for this in the system.

Here's one that a lot of us don't see or really realize and that's the weather forecast, figure 3-25. You know that the National Weather Service has the responsibility of making the forecast for the Aviation Weather System. They of course have been working on this for many years. If we want improved forecasts, the FAA funds for them, tells the National Weather Service what we need, and they do the work on it. Now within the last year and a half--for 233 terminals--they have come up with automated forecasting to assist their forecasters. Verification of the forecasts for these 233 terminals shows a vast improvement compared to what we had in the past.

More recently, they came up with a 2-to-6-hour forecast--a new type area forecast for thunderstorms. This is available; it has been implemented. It covers the area from the Rockies to the east coast and it is only available on request, reply on service-A. But it is available and it is a new product.

Figure 3-26 shows a weather radar that is remoted over telephone lines. We ran a test on this system at the Wiley Post Airport Flight Service Station in Oklahoma. The weather radar was at the National Severe Storms Laboratory. The information presented can have up to six levels of reflectivity contoured. The flight service station air-to-ground found this extremely valuable in helping general aviation pilots in that area. We now have two of these in operation. We've taken the one at Oklahoma City and put it on an enroute radar rather than a weather radar. I will talk about that a little later.

Figure 3-27 is the radar at the radar site. This is the wiring diagram, with transmit mode across the telephone lines to the receiver and then the display. Now if you have someone working with the radar weather returns at the radar site, they can put auxiliary information on the system. In other words, a weatherman can put the cloud height and movement of the storm and that type of information into the system for relay to the terminal. He can identify the most severe areas, so it does have some flexibility.

These two, figure 3-28, that we spoke about: one is at Oklahoma City, and the other is on the enroute radar at Andrews, Texas, to the Midland Flight Service Station. The reason we went on the enroute radar is because they are on the air full time. We had a problem with the National Weather Service Radar in the fact that they take them down for about 15 minutes every hour to height-find and for other meteorological investigation of what they have on the scope. We thought we needed it full time, but we haven't made a complete determination of what radars these will go on. The specification for a major buy of this equipment has been completed. There is a contract being placed and delivery should begin in March of 1979. What we are going to do is put radar information in every one of the flight service stations with Enroute Flight Advisory Service.

Most of you have probably heard of AV-AWOS--Aviation Automated Weather Observation Stations, figure 3-30. We have over 200 flight service stations that take weather observations, and the AV-AWOS program is directed to helping them, figure 3-31. It's one of our programs that supports the FSS modernization program, figure 3-32. What we want to do is provide an acceptable weather observation to the user. It is weather sensors with a computer center and an aviation weather report at the end of the line, figure 3-33. We hope to develop a completely automated weather observation that actually comes close to duplicating what a human can do, figure 3-34. Now in this program--we have been on it for about 4 years--the real problems of automatinon have been dealing with automating sky cover and ceiling, as well as obstructions to vision--this area has been the toughest nut to crack, figure 3-35.

Our AV-AWOS system has been tested at Sterling, Virginia; the National Weather Services Research Facility near Dulles Airport. Our next step is to move that system to Newport News, Patrick Henry Airport, and we are in the process of moving it there right now. We are going to start a user evaluation in October of this year.

What we have in AV-AWOS are these types of systems that measure temperature, dewpoint and wind. These have been rather easy to automate. Around the field we have three cloud-height indicators, and also around the field we have three video graphs for visibility measurement. Information from all of these goes into the computer, which can be located in any space, and the algorithms in the computer then take the information and come up with the weather report, figure 3-36. The information then flows from the AV-AWOS. Weather reports can go over lines to the FBO, approach control, tower, airline pilots, briefing terminals, etc. We also--and this will be at Newport News--have a computer-

generated voice to put out the weather report over the VOR. The AV-AWOS report will automatically go out on service-A through the FSS hub. It can also automatically go on service-A without going through the hub if we set it up that way.

The system will also interface at the Kansas City switch with the AWOS net which is the National Weather Services new high-speed weather distribution network.

Here we have a sample of the report, the way a human takes it today, and what AV-AWOS will report, figure 3-37.

In AV-AWOS, the first thing you are going to see on service-A that is different is that AWOS will come up on there. The next thing, 1,500 scattered, measured 2,500, will show, but you will notice that 15,000 overcast will not. That's because our height finders are ceilometers and will not measure above 10,000, so any ceiling above 10,000 will not show up in the report.

The other area that we are not ready to do yet is rain, fog, and smoke, which we will show as precipitation. We won't identify the type. We can identify hail now, and we are also working on improving this so we will be able to identify the other items, figure 3-38.

Now one of the advantages is consistency, because it's a system that measures the parameters. Another advantage is that we won't just have hourlies. This will give you an observation that is right there on the minute anytime it is pulled. Another thing is specials. It will automatically, through the computer algorithm, determine when a special is needed, and it will shoot the special on the line. It is more representative than the human and that's because it measures the same every time. Where human judgment comes into the reports, a machine will not be influenced. Those locations where we now have just 16 hours of observations will be able to get the full 24 hour coverage with AV-AWOS and a more timely indication of specials.

If we have a power interruption, parts of a manual report may still be able to be sent out. A power interruption in AV-AWOS can be a greater disadvantage, because it really stops the whole report, it prevents you from getting the report and that's basically it. The users are also going to have to adapt to this new system, and that may be a disadvantage during the learning period. At Newport News we are going to test AV-AWOS operationally, figure 3-39. We are going to determine what refinements are needed and also if we can get by on fewer ceilometers and fewer visibility-measuring pieces of equipment. And, of course, we want to get the users' reaction. There will be a questionnaire out for users to come in and tell us what they think of it.

One of our new programs is to come up with a low-cost automated weather station. Nine user groups jointly sent a letter to the Administrator discussing the fact that there are 914 airports that have instrument approaches and no weather observation. As a result of this, we have, in our 1978 funding, a program to develop a low-cost system. We have a development plan already written. We have had meetings with user organizations, internally within the FAA, and with the National Weather Service on determining just what minimum items can be measured and still provide a legitimate report at a reasonable cost.

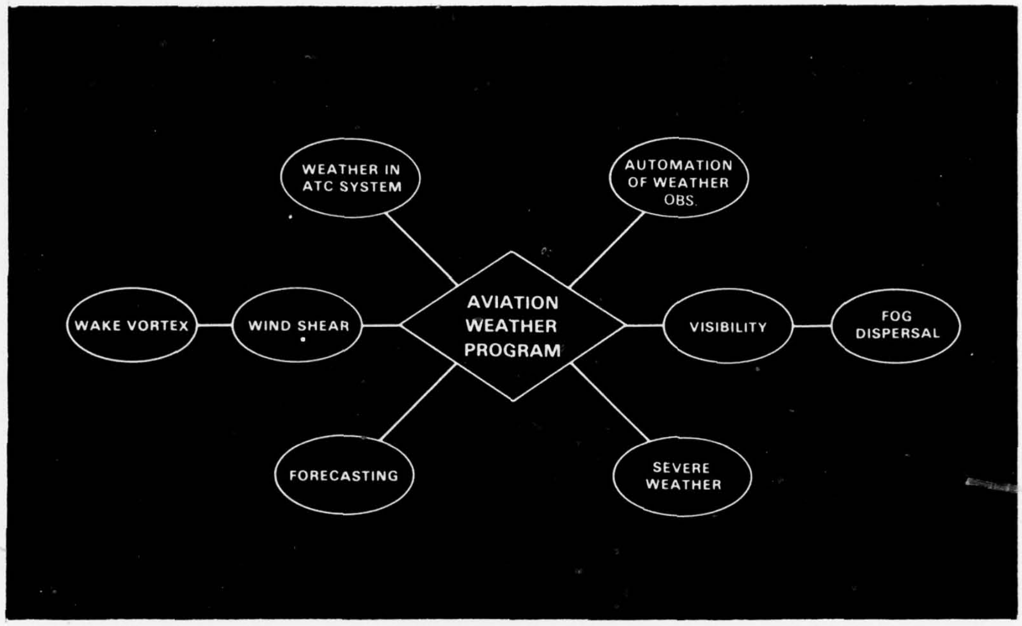


FIGURE 3-17

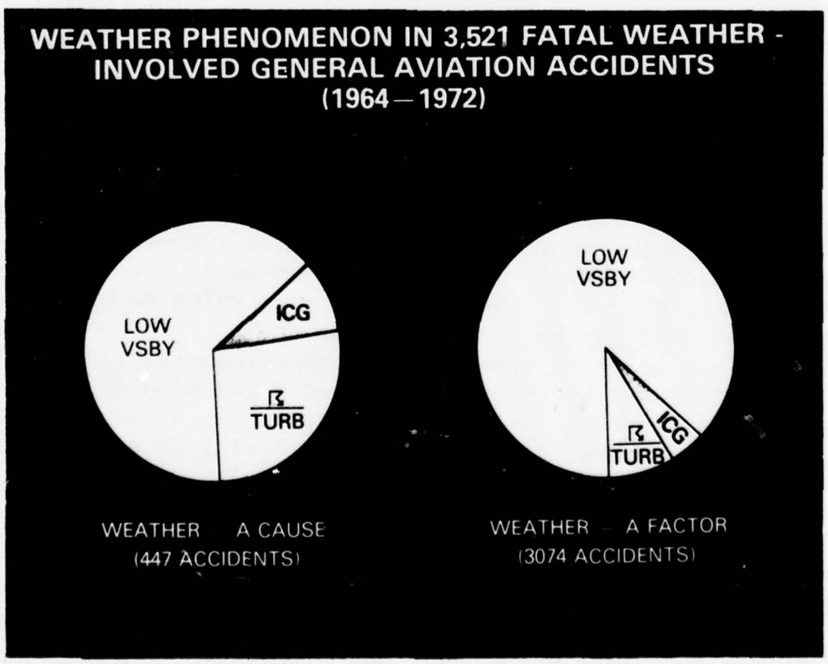


FIGURE 3-18

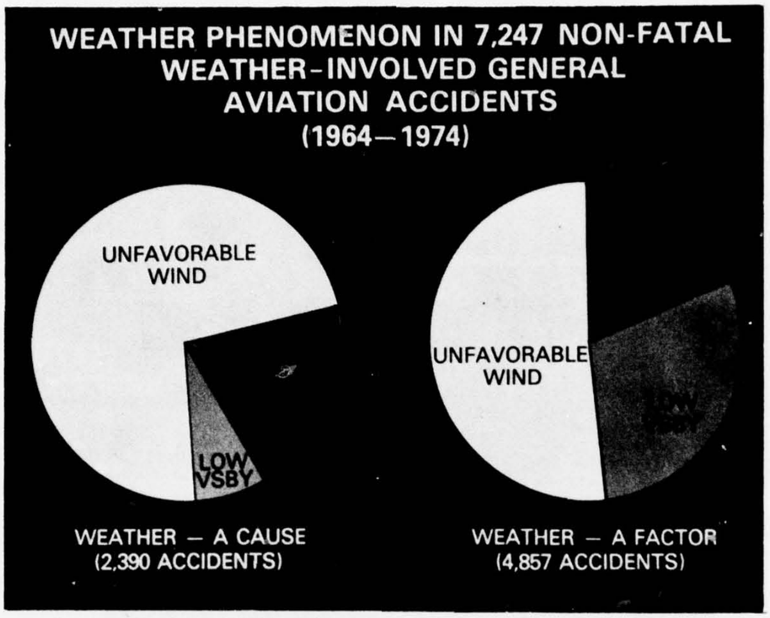


FIGURE 3-19

FIGURE 3-20

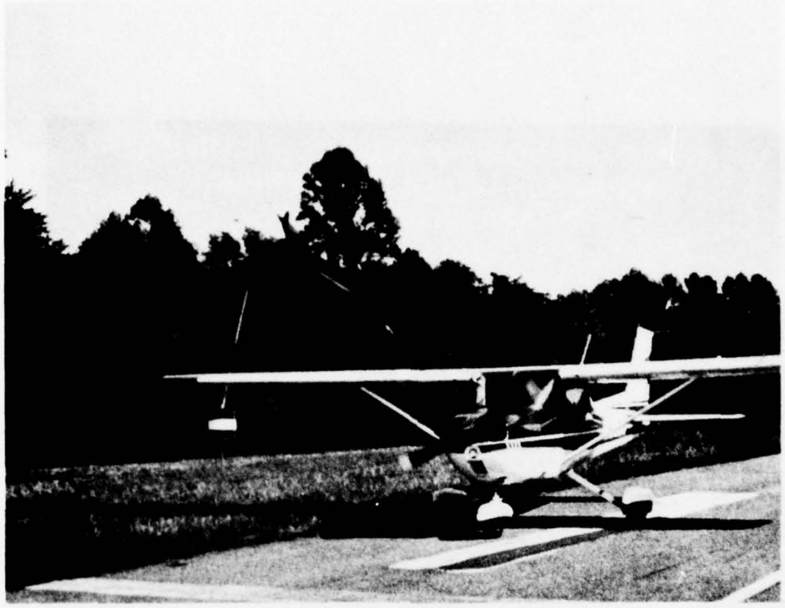


FIGURE 3-21

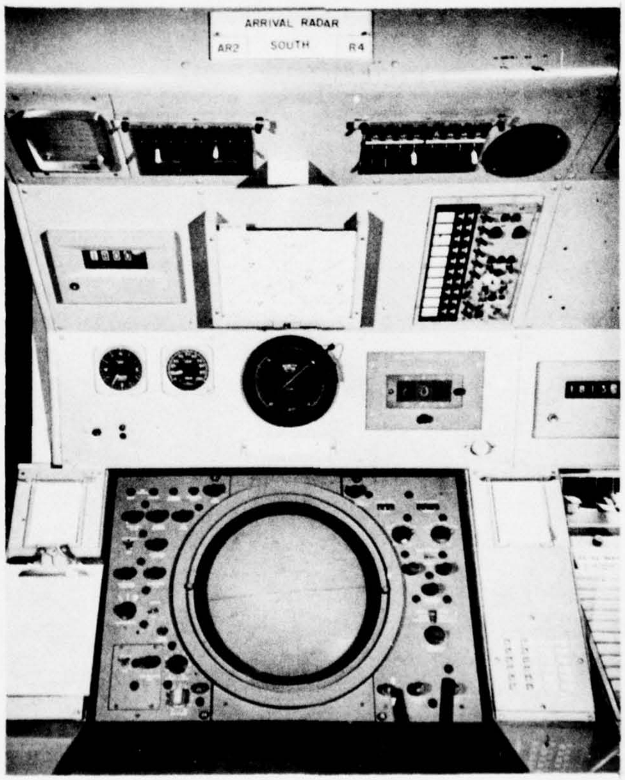


FIGURE 3-22

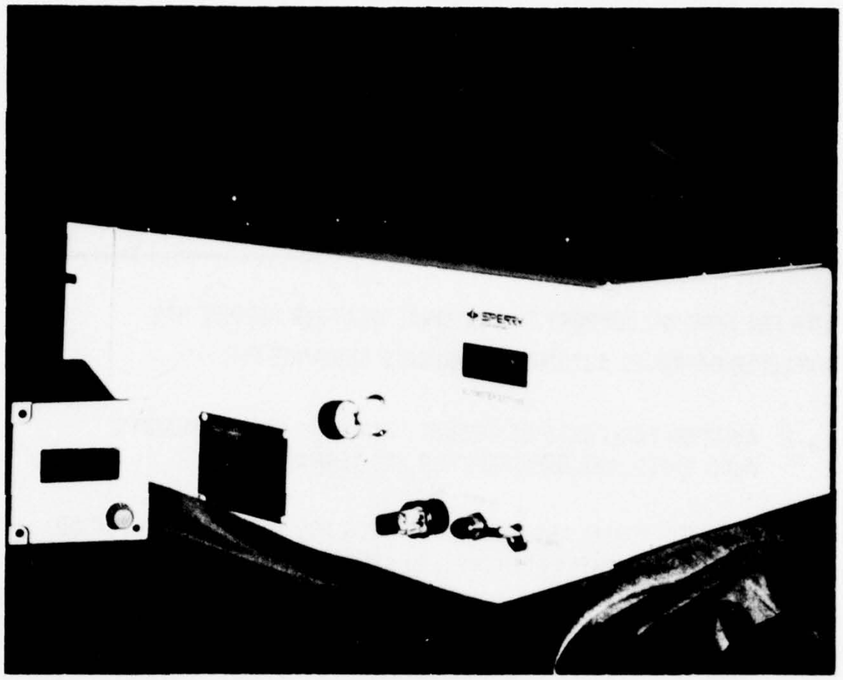


FIGURE 3-23

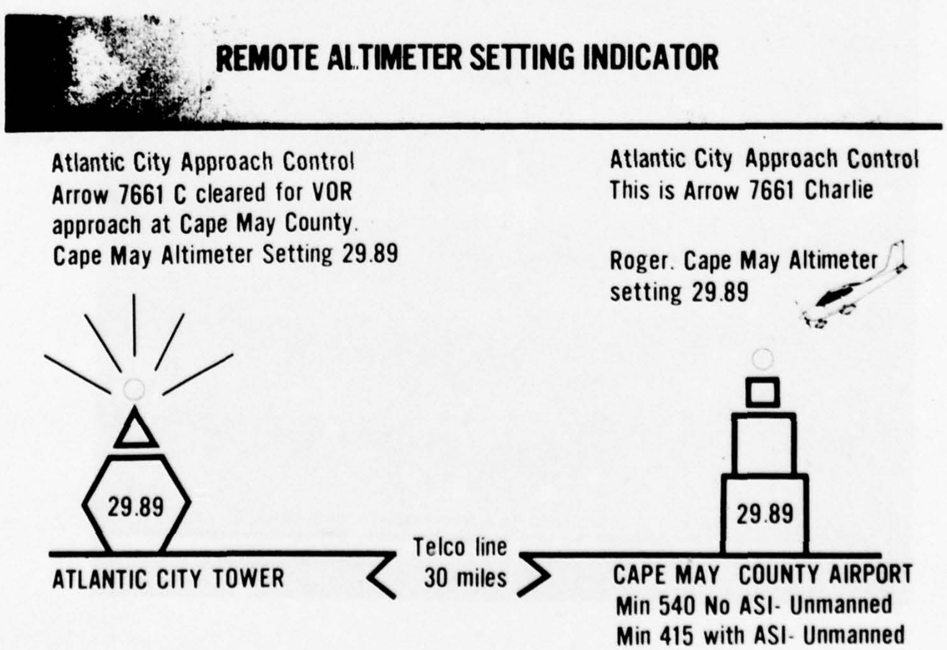


FIGURE 3-24

IMPROVED AVIATION FORECASTS

WITH FAA FUNDING SUPPORT THE NATIONAL WEATHER SERVICE HAS DEVELOPED IMPROVED AUTOMATED FORECAST GUIDANCE FOR:

- AVIATION FORECASTS OF CEILING , VISIBILITY, CLOUD AMOUNTS, WIND SPEED, AND DIRECTION FOR 233 TERMINALS.
- THUNDERSTORMS AND SEVERE WEATHER FOR 2-6 HOUR TIME PERIOD. THIS HAS RECENTLY BEEN IMPLEMENTED.

FIGURE 3-25

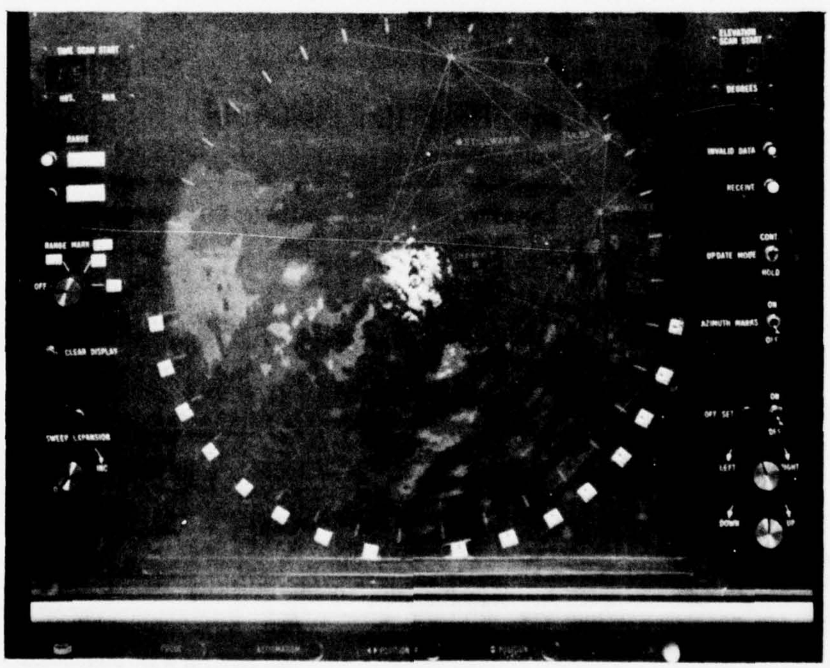


FIGURE 3-26

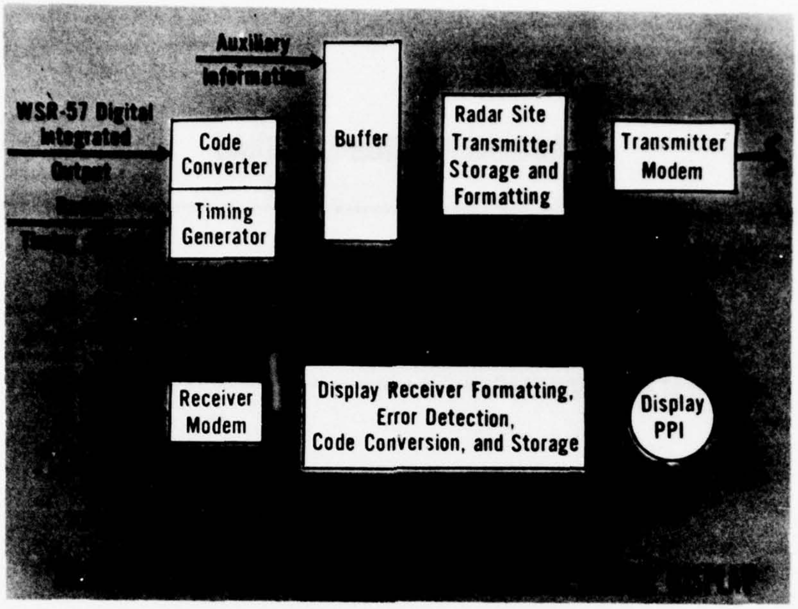


FIGURE 3-27

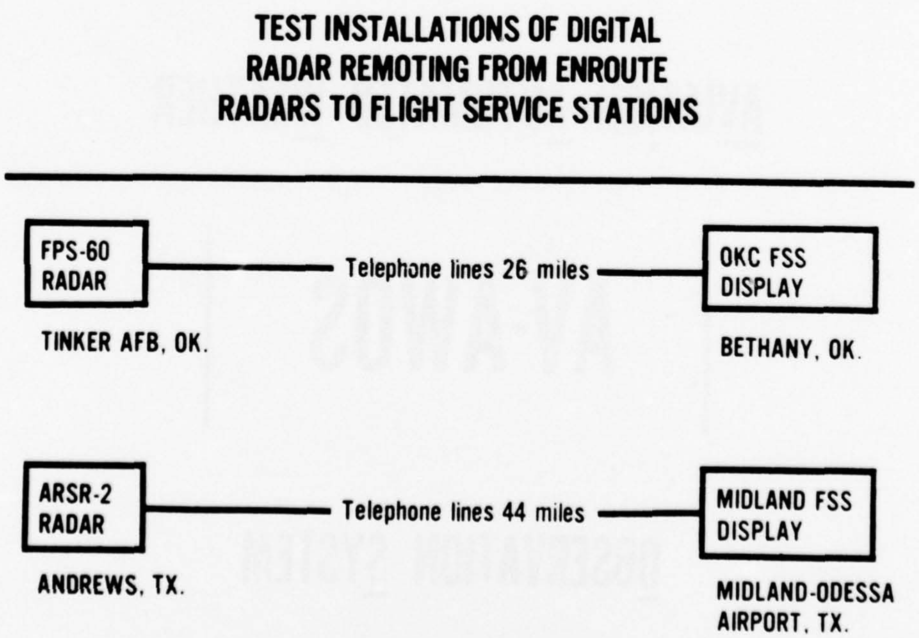


FIGURE 3-28

IMPLEMENTATION SCHEDULE

DIGITAL RADAR REMOTING TO FSS ENROUTE FLIGHT ADVISORY SERVICE POSITION

SPECIFICATION COMPLETED	JULY 1977
CONTRACT PLACED	MARCH 1978
DELIVERIES BEGIN	MARCH 1979
DELIVERIES COMPLETED	DECEMBER 1980

FIGURE 3-29

AVIATION AUTOMATED WEATHER

AV-AWOS

OBSERVATION SYSTEM

FIGURE 3-30

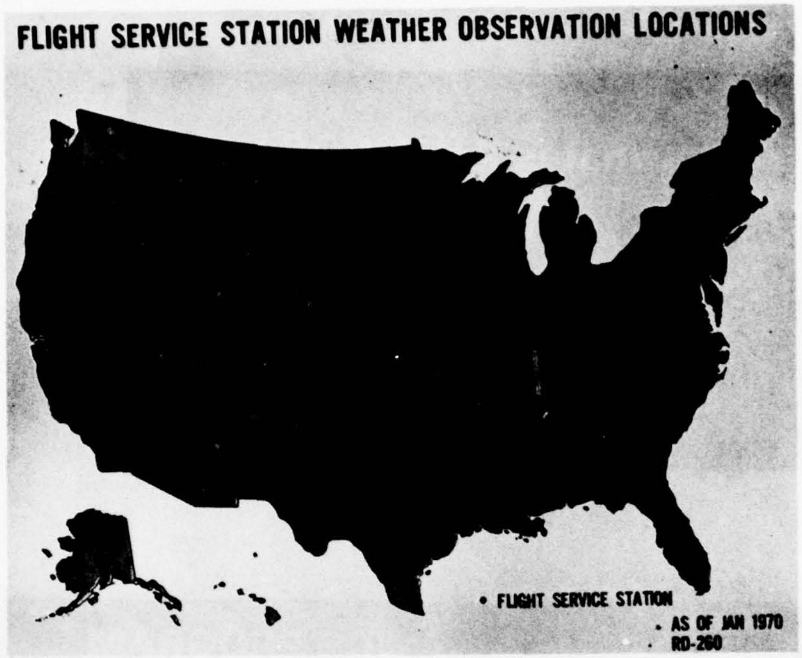


FIGURE 3-31

WHY AV-AWOS ?

- FAA PROGRAM FOR FSS MODERNIZATION

- PROVIDE ACCEPTABLE WEATHER OBSERVATION SERVICE TO USERS AT MINIMUM COST

FIGURE 3-32

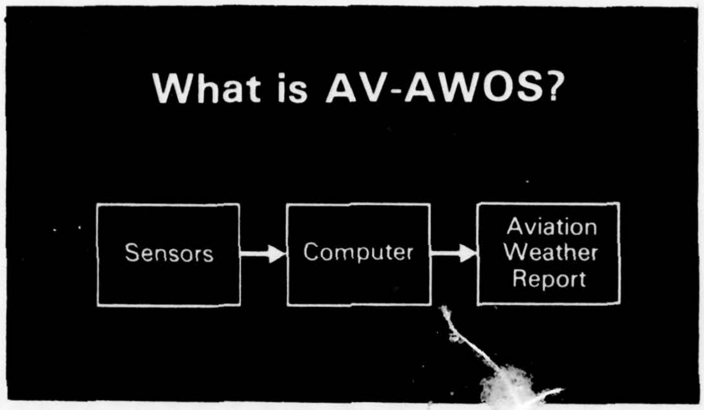


FIGURE 3-33

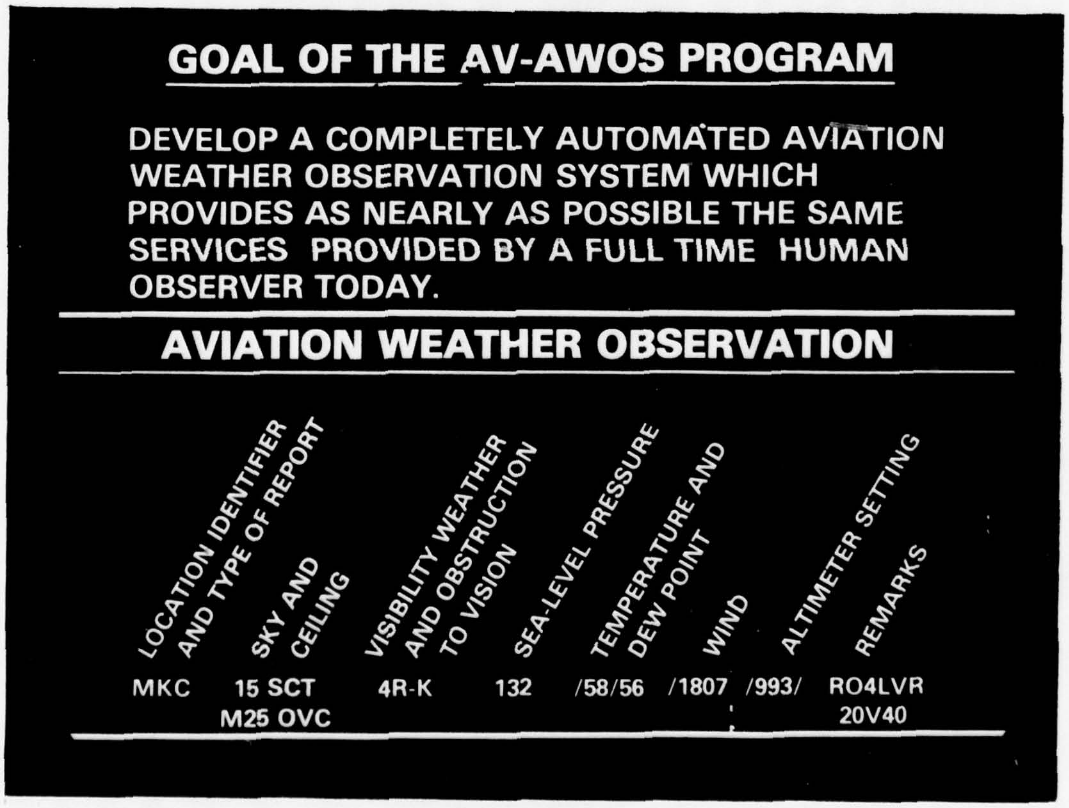


FIGURE 3-34

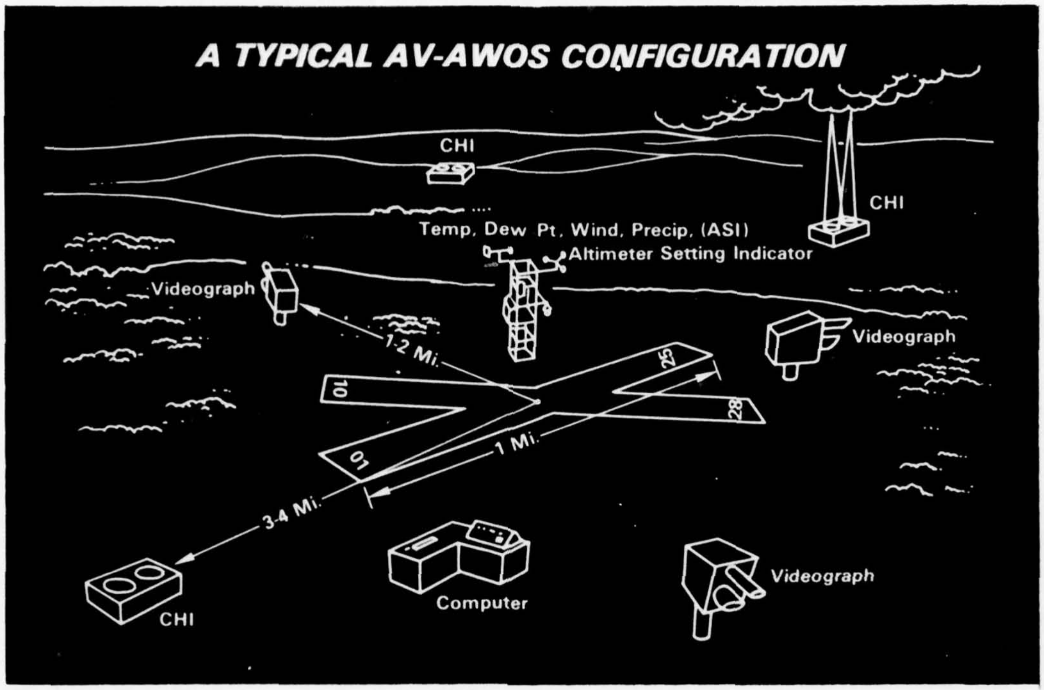


FIGURE 3-35

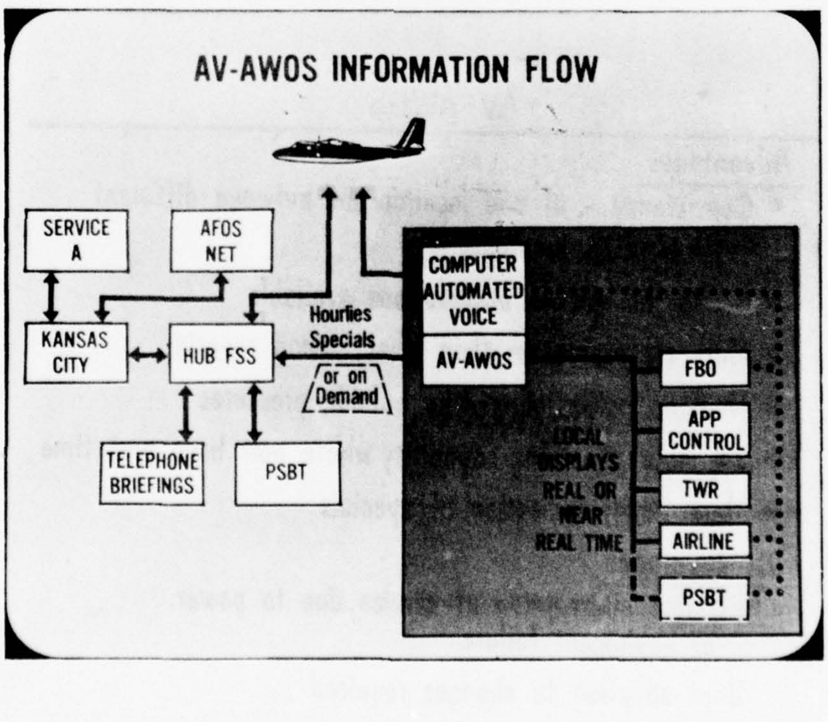


FIGURE 3-36

A Sample of a Possible AV-AWOS Report Compared with a Human Report

TODAY

PHF 15 SCT M25 BKN 1/2V 132/60/58/1310G25/993/
R04VR10V25 VSBY 1/4V3/4

AV-AWOS

PHF 15 SCT M25 BKN 1/2V 132/60/58/1310G25/993/
R04VR10V25 VSBY 1/4V3/4

FIGURE 3-37

AV-AWOS

Advantages

- Consistency - at one location and between different AV-AWOS locations
- Up to the minute observations available
- More representative than what human reports
- Machine not influenced by outside pressures
- 24 Hour observing capability where now have part time
- More timely indication of specials

Disadvantages

Possible interruption of service due to power or equipment failure

User adaption to changes required

FIGURE 3-38

Test of AV-AWOS at Newport News

- Use the System in an Operational Environment
- Determine Need for System Refinement
- Determine Feasibility of Using Fewer Cloud & Visibility Sensors
- Obtain User Reaction to AV-AWOS Observation

FIGURE 3-39

FLIGHT SERVICE SYSTEM MODERNIZATION

MR. ROBERT J. ROCHE

In discussing flight service station modernization, the first thing I want to point out is that we have been working on this program for a long time. Everyone, I think, is aware of that. We know what we must do, and we have met with various organizations, users, other governmental offices internal to FAA, and identified what we want to do.

There have been problems in getting complete agreement on this program, but we did release a masterplan for review in 1976. The major thrust in that plan was automation which provides the weather data base and the automatic capability to access the system for two users: the pilot himself, through a variety of self-help briefing techniques, and the flight specialist in serving the user. The plan identified consolidation and collocation as aspects of the program. It also identified an independent near-term program which would provide limited flight specialists automation in the near-term before the long-term automation systems were in place. Since that plan was released, we have had one major input, and that is direction on the part of Congress which has delayed consolidation for an additional 3 years. We have also solicited and received comments from users and other governmental agencies.

We are now finalizing the plan and hope to release it in the coming month. This plan has the following features: (1) it combines the near-term and long-term automation into an automation program where we can go out with an initial capability and build on it into the long-term system; (2) it emphasizes implementation of the automation features of the program while being transparent to the consolidation issue which is the major controversial issue in the program; (3) it provides for decision points to be made regarding consolidation; (4) the long-term program includes consolidating to fewer manned facilities.

During this briefing, figure 3-40, I am going to give you an overview of the entire program and the FSS system in general including the historical development; present problems, benefits associated with the program; and our plan and implementation schedule.

The FSS system that has evolved over the years was not designed and is not in place as an engineered system, but rather evolved starting back in the 1920's with bonfire attendants along the original air mail routes, figure 3-41. In the 1930's the system was expanded primarily along the old lighted airway routes. The stations provided communications, relayed messages, and took weather observations. Those functions expanded into the 1940's.

Major communication networks for weather, air traffic control messages, and flight plans evolved, and the primary function, in addition to the weather observations, was relaying air traffic control messages into remote areas. The number of flight service stations was at its maximum in that period of time. We have since reduced the number to approximately 290 stations in the conterminous states today.

The major functions today are weather and NOTAM information, providing the pilot, the major user of the system, with preflight weather briefing and in-flight service, figure 3-42. The system still continues to relay messages for the air traffic control system and is the major communications network for VFR flight plans and for the input of IFR flight plans primarily from General Aviation and military. Emergency assistance and other functions including weather observations also remain in the system.

Most are aware of the deficiencies of today's system, particularly in the large metropolitan areas, figure 3-43. Users get busy signals far too often when they call in to file a flight plan and get a weather briefing. It is a system that we have described in various terms. Equipment is obsolete. It is a paper system, the stations in remote areas have low productivity. It is not because the people out there don't want to provide the service. They are waiting, in fact, to serve; they are waiting for the next call, and as a result their productivity over a year's time is lower.

Many stations have not been physically improved in many years. They do not have ideal working conditions. We have a high overhead associated with the system due to the large number of stations. Now, in all of these words, I don't want to reflect anything adverse regarding the flight specialists themselves. They are very dedicated employees in our system, and we have to commend them for continuing to work in this environment, waiting for the improved system.

This is a very typical picture of the existing flight service station, and you can see the paper products, the facsmimile maps on the wall, the obsolete communications, and teletype equipment still in use today, figure 3-44.

In addition to the problems I already mentioned, we have an ever increasing number of general aviation aircraft in the fleet today: 160,000 aircraft projected to grow to around 320,000 by the year 1995, figure 3-45. As the fleet doubles, the forecast number of services increases even faster, because we are talking about an increasingly sophisticated fleet. We are talking about pilots who require more services. Consequently, the number of services will nearly triple by the year 1995. The current system, in terms of providing flight services to the user, is essentially only capable of a one-on-one relationship, i.e., the pilot calls in to get a weather briefing or he walks in and files a flight plan, figure 3-46. Our annual costs today total nearly $150 million, with 85 percent of those annual costs for staffing. The situation is such that if we were to continue on in the future to provide services as we do today, our annual costs would go up in a direct relationship to demand, resulting in a near tripling by the year 1995, primarily by having to increase staff to meet that demand. If we held staffing constant and didn't do anything to the system, we would have a deteriorating situation in terms of our ability to meet the pilot's needs.

Figure 3-47 is designed to give you an understanding of our solution to the FSS problem, where the benefits lay, and the magnitude of those benefits. The

major benefit in the program, as we are planning it, is in the area of pilot self-briefing. This is a statement I would like to use in its broadest terms. It includes improved mass weather dissemination, the cheapest, lowest cost way (10 to 15 cents per service) we can provide weather and aeronautical information to the user that also often totally satisfies his need for a weather briefing. Pilot self-briefing ranges from improved mass weather dissemination through several intermediate options to a full capability being a CRT terminal or a printer device. One method, turning out to be the most promising, is accessing the system through the touch-tone telephone, keying in location identifiers and getting a computer-generated voice response with a tailored briefing. We are also developing the capability for filing a flight plan this way. In the self-briefing area above, we anticipate saving annual costs in the order of $150 million a year by the year 1995. The next largest area of benefit comes from consolidation which eliminates the low-productivity stations and their overhead. I am going to say more on this subject a little later. The third area of benefits comes in flight specialist automation. It is the smallest in terms of measurable dollar benefits. We eliminate functions---the man walking around the station distributing the teletype paper and the service-A teletype paper. We can eliminate the teletype functions completely. But in the area of giving a weather briefing, our measurements show that it actually takes the briefer slightly longer. However, he is giving a far better briefing, a measurably better briefing. Consequently, we are improving the quality of service. For example, in today's system, the speed that weather information goes around the country is at 75 to 100 words per minute (teletype speed). We get a weather observation, originally taken about 5 minutes before the hour to the next service station on Service-A after going through the weather message switch, anywhere about 5 to 15 minutes past the hour. A pilot report (PIREP) is usable at the station where it comes in, but at the flight service station 75 miles away, it may be three-fourths of an hour before it is even received. In contrast, the modernized system with automation and modern communications, can get the weather observations to the specialist in a matter of seconds. The same thing is true with pilot report's. The pilot report is called in, the specialist keys it into the system, and within seconds it is distributed to every station and every specialist. I want to concentrate on these three areas in a little more detail, figure 3-48. In the area of self-briefing, of course, today's system is the one-on-one; and we want to eliminate that as much as possible. That's going to happen gradually over time. By the 1990's, we are hopeful we can shift at least 70 percent of the workload from the specialist to the user through a variety of means including mass weather dissemination. In the original DOT report on FSS that was conducted in 1972, there was a very optimistic goal of 90 percent. We have lowered our sights considerably here, but we do think by the 1990's 70 percent is achievable. I have mentioned a variety of devices. Our goal is that the pilot can access the system from wherever he is located, his company, his office, fixed-base operator, or home with a variety of terminals, figure 3-49. I want to just mention some of the things we have been working on.

This picture shows a self-briefing terminal, figure 3-50, this would be the maximum capability. FAA does not anticipate deploying self-briefing terminals.

We are building the capability into the system so those users with the terminals can access the system. A far cheaper terminal, but one that can get as much information, would be a modern printer terminal, figure 3-51. A suggestion which came from a pilot from the AOPA headquarters to have an electronic device on a home TV set and use the TV set as a terminal has been developed by us and is turning out to be quite successful, figure 3-52.

This illustration shows other remote terminals, figure 3-53. This particular device is a hand-held terminal which did not prove to be very effective. However, we are seeing such a rapid change in technology in the area of small hand-held computers using a variety of readout devices such as paper strips, etc., that we can see the pilot having a small pocket-type terminal at a very low cost in the next 4 or 5 years.

Again, the most promising self-briefing technique is the computer-generated voice response, figure 3-54. We have successfully developed this capability; however, a lot of work has to be done with the National Weather Service to get the unique products and to clear up the weather data base so that it is completely usable in this environment. The simple weather reports are easy to use like the SA or the FT, but when you get into an area forecast, the vocabulary becomes very large. We are working with the National Weather Service for improvements in this area. I might comment that we are planning a demonstration in the Washington, D.C., area in the coming year to demonstrate the voice response capability for both weather briefing and for filing a flight plan.

Secondly, the consolidation I have said a lot about, figure 3-55, the long-term goal is to consolidate into a few manned stations collocated at 20 ARTCC sites. Just to give you an indication of productivity in the system, our large flight service stations, Level III's, of which there are 45 FSS's in that category or one-sixth the total, provide 42.5 percent of the total services, figure 3-56. The Level II stations, the smaller but still active stations, representing slightly over half of the stations, provide slightly less than half of the services. The remaining 78 smallest stations out in the remote areas provide 8.2 percent of the services. Figure 3-56 indicates the levels of productivity from a maximum of 25,000 flight services per year in the largest stations down to slightly over about 12,000 services per specialist per year in the low activity stations. So you can see where the benefits come from consolidation---making the people we have more productive.

Our first step will be to implement a limited automation capability and improvements into the flight service stations that you see in the larger circle, the Level III stations, in the metropolitan areas where there is the greatest demand. We ultimately plan to consolidate to as few as 20 stations, figure 3-58. Figure 3-59 is a picture of the facility at Atlanta---the prototype flight specialist automation system, AWANS. Here, the specialist pilot has the aid of the computer in the briefing. Figure 3-60 is a picture of our prototype facility at the Leesburg Center.

We see today the specialist is involved in providing services on a one-on-one basis. Let's go out to the 1990 time frame, figure 3-61. We expect the workload will drift from the specialist to the pilots themselves, and the number of

specialists will actually decline. Our annual cost will grow in the first few years because of the capital cost for implementing the system, figure 3-62, but then will substantially drop to a level about equal to the annual cost of today's system or around $150 million dollars. However, we will be providing three times the services.

Now, for our implementation plan, figure 3-63. In the near-term, Phase A, improvements to mass weather dissemination are continuing. EFAS, Enroute Flight Advisory Service, has been implemented across the country; and starting near the end of the decade, we plan to begin implementation of limited automation; and then in 1982, implementation of full automation, first in the Level III stations. In that time frame, the decision will be made on consolidation. And, in that sense, depending upon the configuration mentioned earlier, our automation systems will be transparent to whatever decisions are made, and we can continue to automate existing flight service stations. We can contract into any configuration. Our long-term planned configuration remains the 20 consolidated collocated stations.

Thank you.

FIGURE 3-40

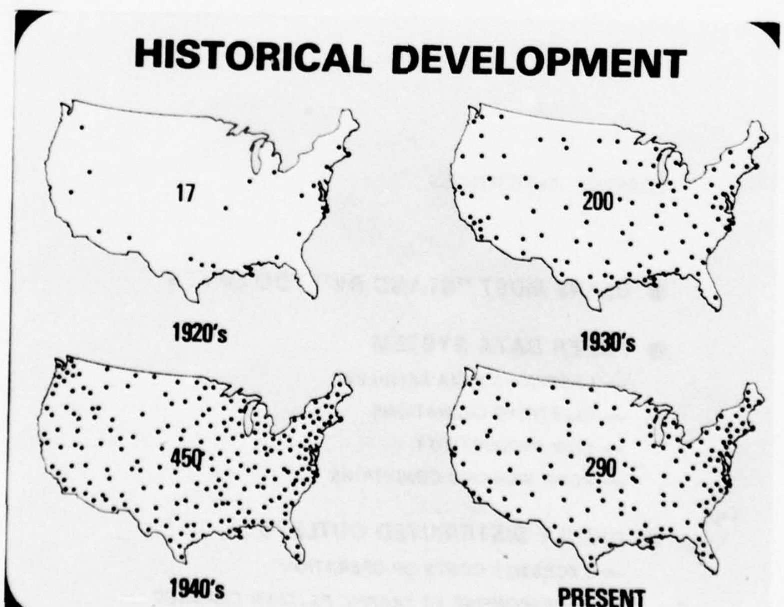


FIGURE 3-41

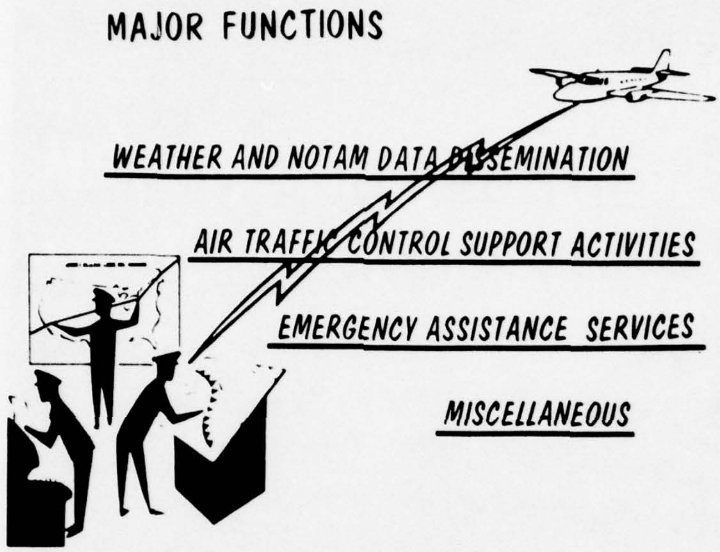


FIGURE 3-42

CURRENT DEFICIENCIES

- **USERS MUST "STAND BY" TOO OFTEN**
- **PAPER DATA SYSTEM**
  - LABORIOUS DATA RETRIEVAL
  - REPETITIVE OPERATIONS
  - LOW PRODUCTIVITY
  - POOR WORKING CONDITIONS
- **HIGHLY DISTRIBUTED OUTLETS**
  - EXCESSIVE COSTS OF OPERATION
  - UNRESPONSIVE TO TRAFFIC PATTERN CHANGES

FIGURE 3-43

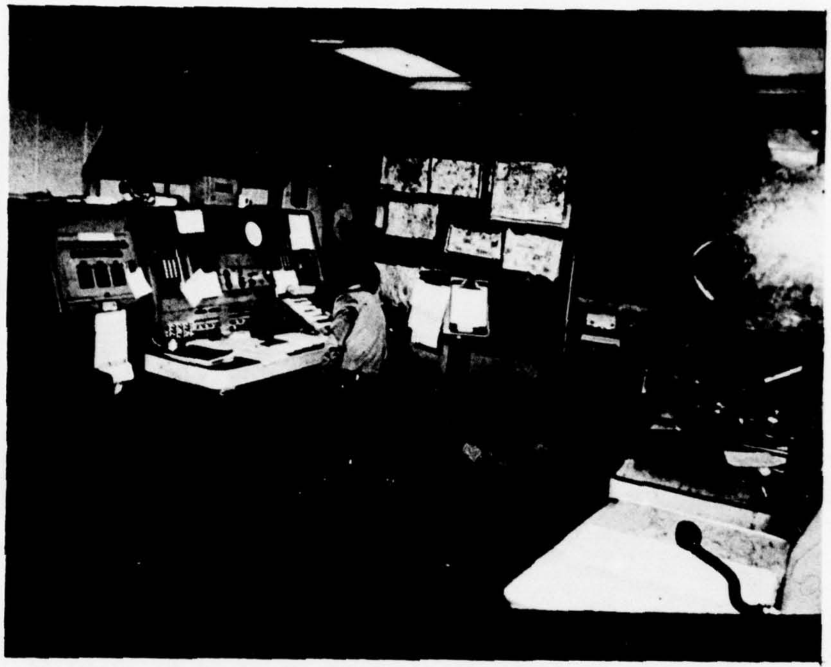


FIGURE 3-44

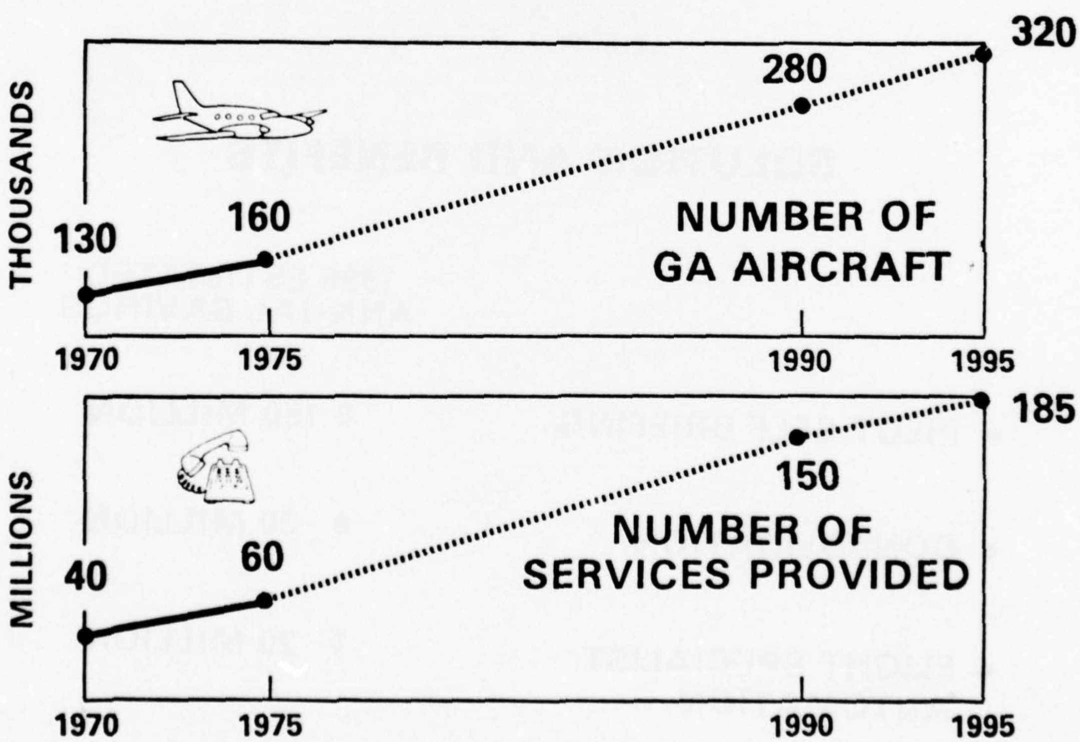


FIGURE 3-45

ANNUAL COSTS

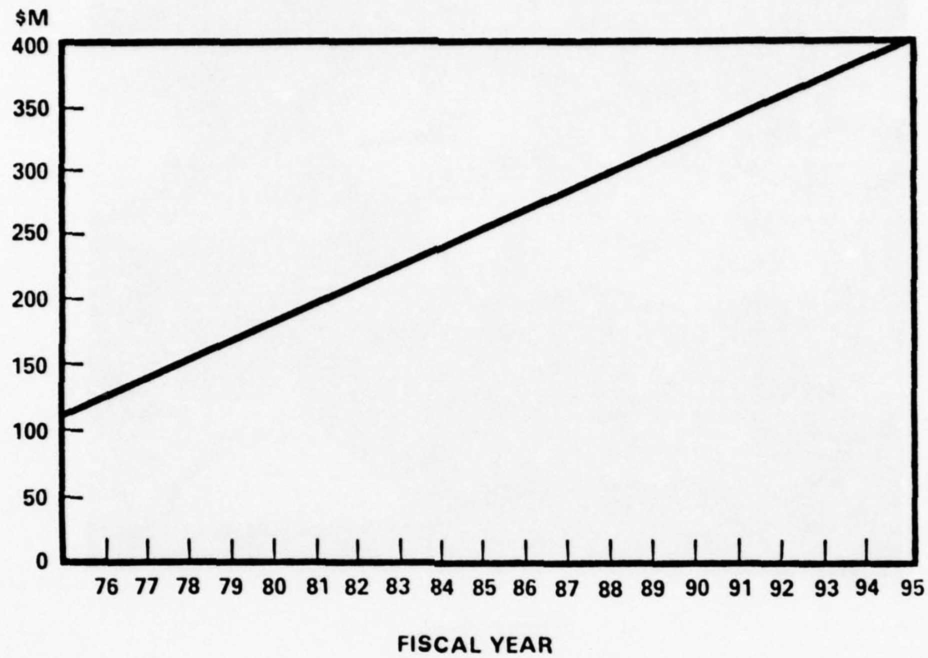


FIGURE 3-46

SOLUTION AND BENEFITS

	1995 ESTIMATED ANNUAL SAVINGS
• PILOT SELF BRIEFING	$ 150 MILLION
• CONSOLIDATION	$ 30 MILLION
• FLIGHT SPECIALIST AUTOMATION	$ 20 MILLION

FIGURE 3-47

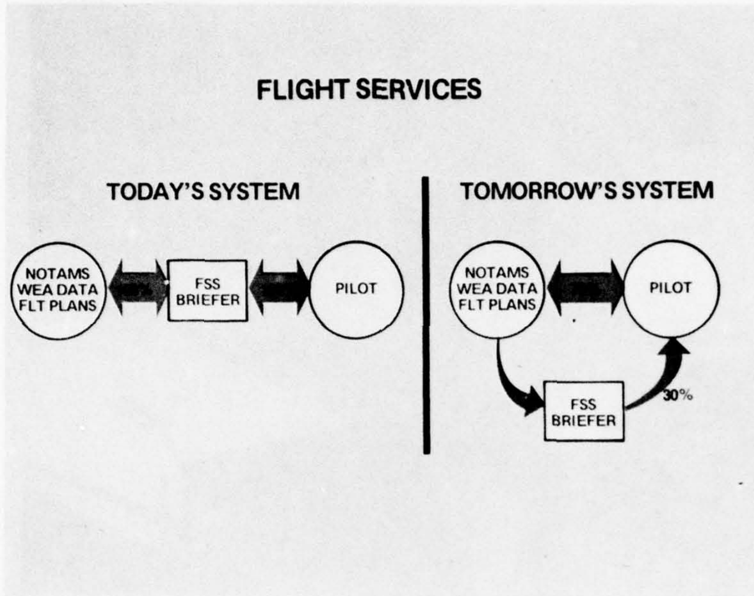


FIGURE 3-46

FIGURE 3-47

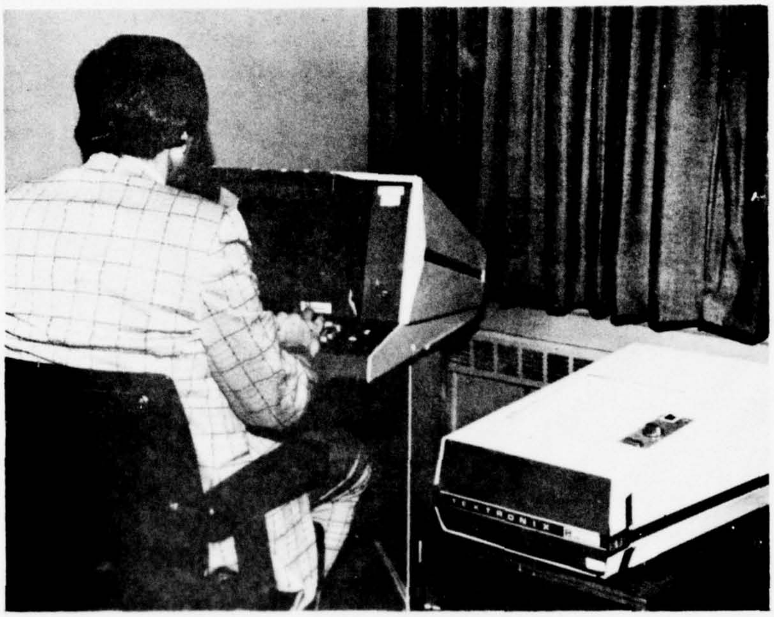


FIGURE 3-50

FIGURE 3-51

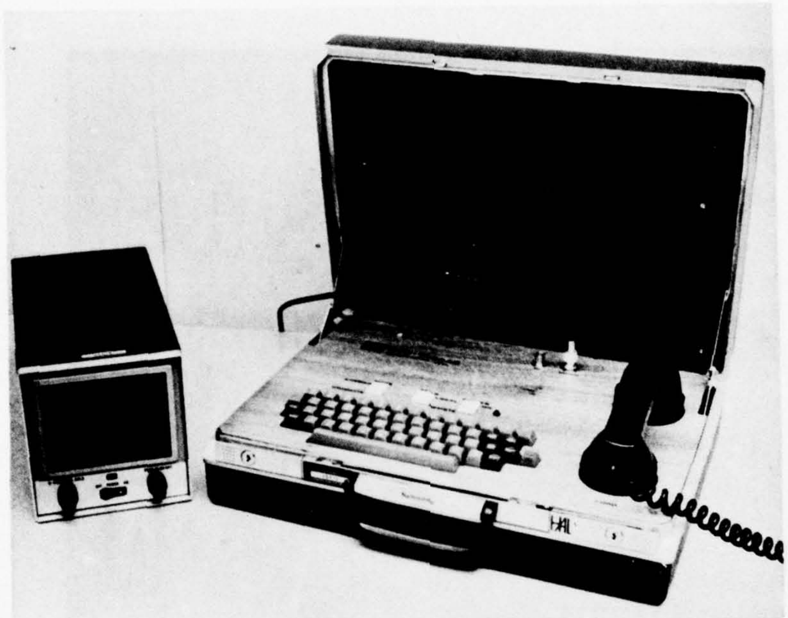


FIGURE 3-52

FIGURE 3-53

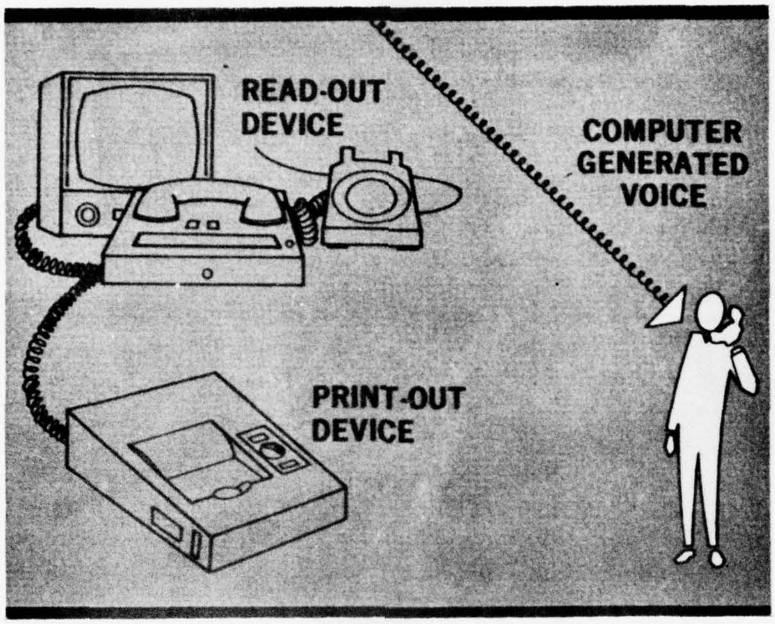


FIGURE 3-54

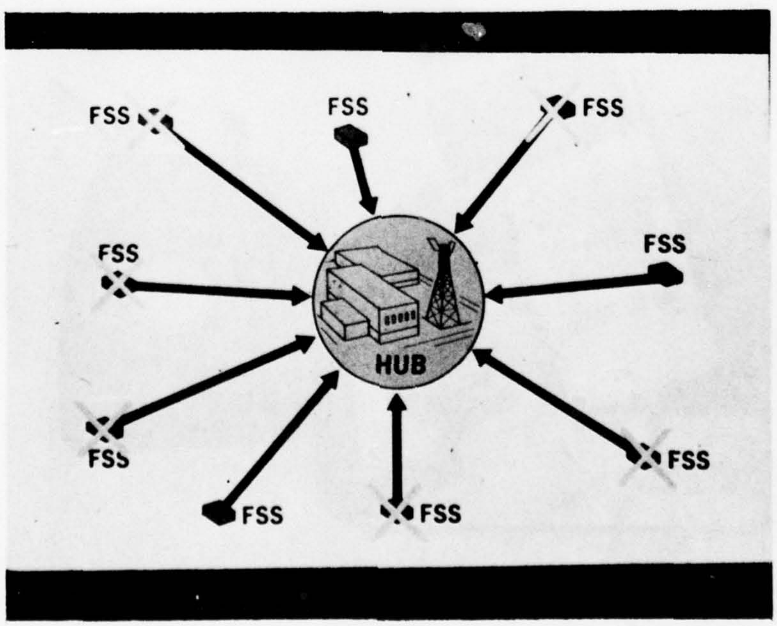


FIGURE 3-55

FSS PRODUCTIVITY

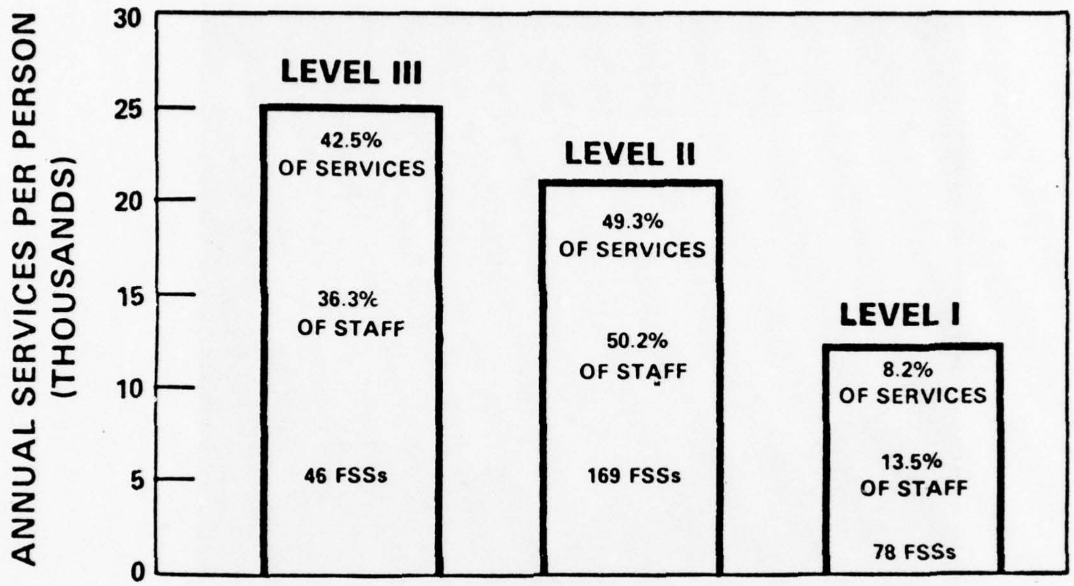


FIGURE 3-56

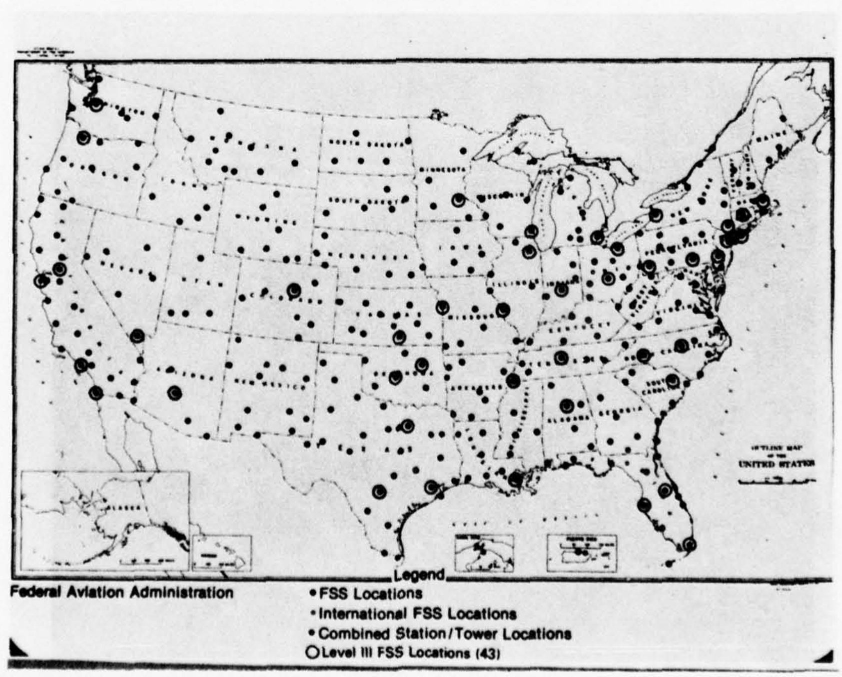


FIGURE 3-57

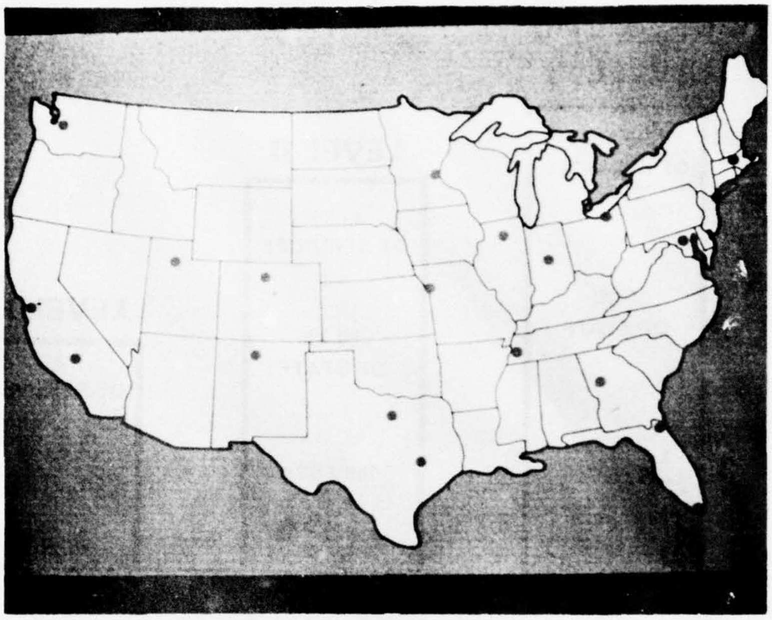


FIGURE 3-58

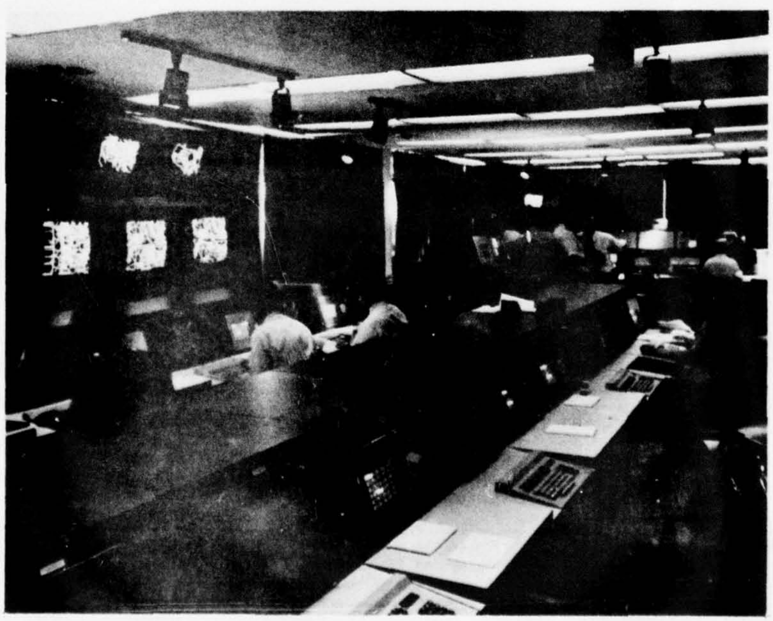


FIGURE 3-59

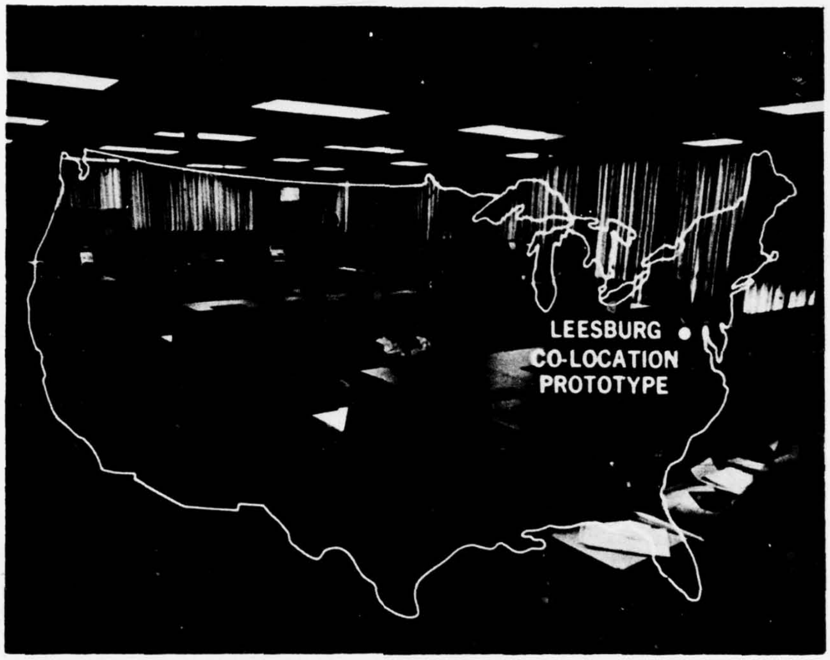


FIGURE 3-60

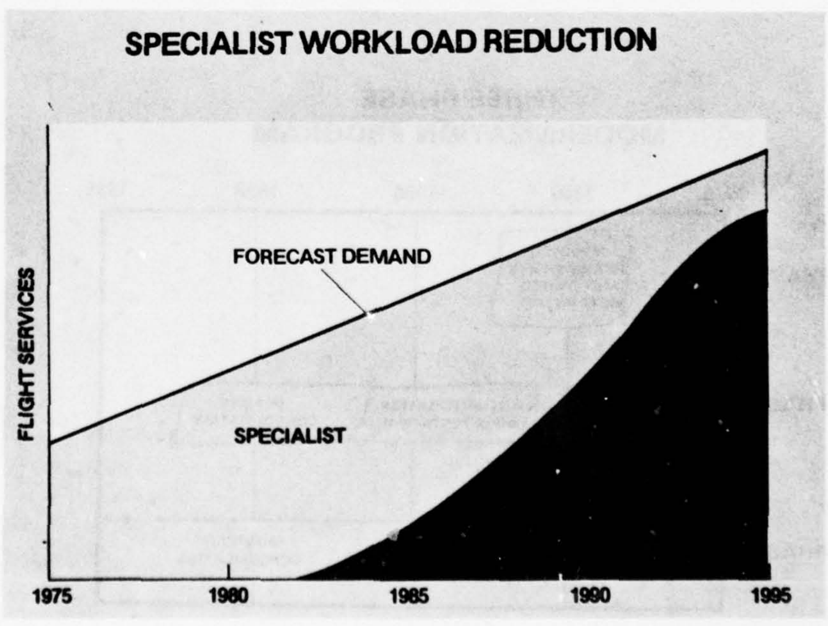


FIGURE 3-61

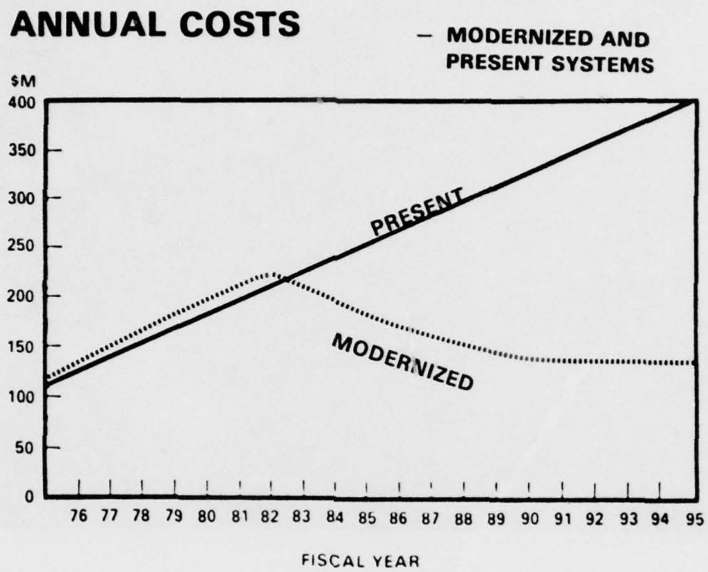


FIGURE 3-62

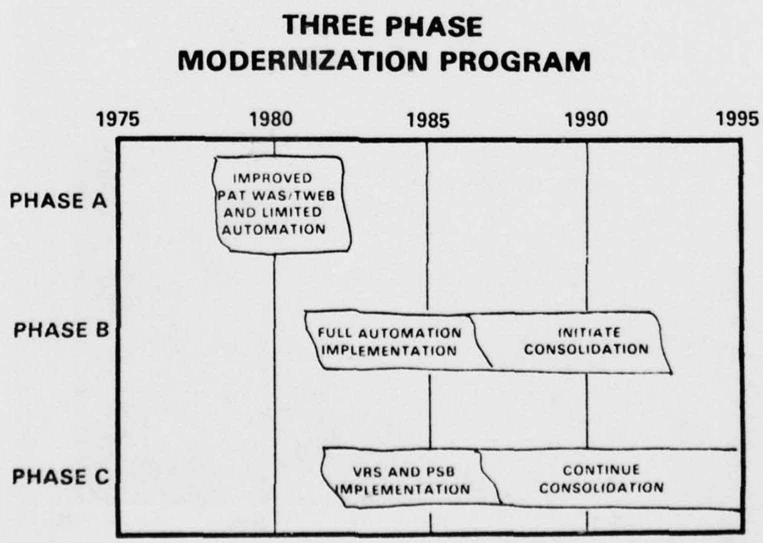


FIGURE 3-63

A GENERAL AVIATION USER VIEW ON WEATHER AND FSS MODERNIZATION PROGRAMS

MR. LARRY LANGWEIL

Our final presentation in this session will be a "General Aviation View on Weather and FSS Modernization Programs." To provide us this view, we have with us a very effective, articulate and forceful proponent of the general aviation user position. In the past, when he has perceived the FAA's straying from the correct path, we can be sure, just like death and taxes, that he would, in some forceful and sometimes uniquely painful manner, succeed in bringing it to our attention. And, I am sure that he will continue to do this, probably this morning. He is a senior vice president for policy, technical planning of the Aircraft Owners and Pilots Association, and at this time I would like to introduce a gentleman I am sure all of you know, Mr. Victor Kayne.

MR. VICTOR J. KAYNE

Thank you, Larry. I hate to tell you all, but you have to stay awake. I don't have any viewgraphs, the lights are going to stay on. I offered a couple of times to the FAA to break all of the viewgraphs over there and that will cut the speech making in half, at least. I think that, in FAA, viewgraphs seem to have the same status as a key to the executive washroom in the big corporations. You have to have viewgraphs to make a speech. I note by the program that this is the time for a question and answer session. I was just kidding Larry about this equal time because I have 15 minutes. I have to cover both the general aviation weather and the FSS, which were covered, 20 minutes each, by my two predecessors. I think we will make out. I do want to say at the outset that I am going to be rather brief on this talk, I hope. I do have 200 copies of my presentation on the table so there should be enough to go around and you can read the complete text of it.

Both the weather requirements and the FAA question are two subjects that have been with us quite a while. Incidentally, one thing I wonder, the FAA spend s a lot of time on noise measurements, you know, we measure the Concorde coming and going and everything else, I wonder if anyone thought about bringing a noise meter in here to measure this cotton picking thing that is going outside here. You already heard Joe Sowar who covered a little of my talk. He did tell you that nine aviation groups did get together to come up with a consolidated requirement for aviation weather. I covered both the general aviation community and air taxi and commuter groups. There is one thing that a few people are not familiar with, and that is that the Congress, long ago, vested in the FAA the responsibility for determining the aviation weather requirements. With the FAA having this responsibility, they also have the responsibility to advise the National Weather Service (NWS) so NWS can proceed to include those requirements in their budgetary process for implementation. The FAA determines the aviation weather requirements; they advise NWS and NWS is supposed to carry it out. Now one of the earliest brushes that we had with this

divided responsibility was some 15 years ago, when we found that the then Weather Bureau was mistakenly working under assumption that their only responsibility for weather was to the scheduled airlines. We have since had that impression corrected.

Attached to my printed copy of this talk is the joint letter that Joe talked about that was put together by nine organizations, and it goes into detail in those recommendations. However, I can summarize it in part, and it already has been pointed out that the weather has been cited as the cause or factor of 4 of every 10 fatal accidents, and 2 of 10 of nonfatal accidents in general aviation for a number of years. Now the general-aviation accident rate could be improved substantially if accurate and timely weather information could be obtained readily by general aviation pilots. Despite significant progress, capabilities, and large efforts in research and development, there has been little progress in providing weather observations at the growing number of general aviation airports that have either, or both, a published instrument approach procedure, or a large number of based aircraft. AOPA went out a short time ago, we put our money where our mouth is, and we contracted with a gentleman who is sitting in the audience today, Mr. Sam Wyatt, who is pretty well known around the industry for his long tenure with the National Weather Service and the Weather Bureau before that. Sam did a study on all airports with approved instrument-approach procedures and then correlated that with how many had weather observations, how they were made, the number of instrument approaches made at the airport, and so on. That is where we get the figure that Joe came up with out of 1,707 airports with approved approach procedures, 914 had no weather observation service. This puts you in a little bind, for those of you who fly instruments, or fly at all, on going out and making an instrument approach to a place with no indication as to what the weather is before you start to shoot the approach. Now, we know that it is neither economically feasible nor practical to put U.S. Government people at all of these airports where weather observations are required. We also realize that to train nongovernment people places a burden on National Weather Service. Now with this in mind, the nine groups jointly determined what they believe to be a realistic minimum requirement for weather observations at general aviation airports. The objective was to specify only those elements of weather that have a significant influence on safety and, where practical, be susceptible to observation with direct readout by uncertificated airport personnel, such as airport Unicom operators. This ties in exactly with the work that Joe has described. The following elements were recommended as minimum requirements for observations at a single site on an airport: height of clouds at or below 5,000 feet, visibility or visual range, wind direction and velocity, temperature, and altimeter. Then, there are some additional elements considered desirable, but not really essential: dewpoint, precipitation, peak gust, average trend and prevailing cloud height, and obstructions to vision. The nine associations recommended the FAA use its authority under the Airport and Airway Development Act to make grants to states and other eligible bodies for the purchase of approved manual or automatic weather observing equipment. They also recommended that the National Weather Service be staffed to cooperate fully with any purchaser of weather-observing equipment in providing training or certification of observers as required. They recommended that the FAA field test simple cloud height

and visibility measuring devices, such as automatic ceilometers and backscatter devices, to determine their operational usefulness if the measurements are read by uncertificated personnel or the information is transmitted automatically to pilots or to a collection station. They further recommended that, to the extent operational tests prove feasible, the FAA use cloud height and visibility to define landing and takeoff weather requirements if appropriate to the type of operation involved. We have had acknowledgment of those recommendations from both Brock Adams and Jaunita Kreps, but we are now awaiting to see how much action goes forward.

Now, to get on the subject of flight service stations. This, too, is not a new subject. In 1967, 10 years ago, AOPA participated with other groups in the development of an FAA plan to modernize the flight service network in place, not consolidated, but in place. Unfortunately, this plan was not approved by the Office of Management and Budget, which indicated that modernization of the existing facilities was not cost effective and the system would have to be consolidated for economic reasons. That's where the consolidation came from.

Early in the 1970's DOT and FAA, with OMB encouragement, developed a centralized plan of 30 manned hub stations and 3,500 unmanned outlets for use by pilots at 2,500 airports. Those unmanned outlets are what we have been referring to around here as pilot self-briefers. The term has been expanded somewhat since then as Bob Roche tried to convey. Frankly, pilot self-briefers got to be a dirty word with practically everybody in the general aviation business. This plan was based on a false assumption that pilots go to an airport for their briefings. You had to go to the airport even if it was the middle of the night and the airport was closed. That was the only place you could get it. Actually most preflight briefings are conducted by telephone. Secondly, and most important, the time table in the 1970 plan called for the continuous decommissioning and consolidation of a number of stations each year before the automated equipment and concepts proved themselves and were available. Thus, service would deteriorate before it got better. So strong were our objections, and those of other people, and again AOPA put its money where its mouth is, and we went to court to seek an injunction along with the city of Youngstown, Ohio, to keep a flight service station open and supported Congressional legislation that prohibited the FAA from decommissioning stations until an FSS modernization plan was proven and available. That prohibition has been again renewed and is still in effect. Of course, we don't want anymore decommissioning until we see something that will work and see it start to get in place. As a counter-proposal to that DOT/FAA plan, the general aviation groups, AOPA among them, with six other groups, prepared their own plan in 1974, based on existing and future general aviational needs.

These recommendations incorporated pilot access by way of the most commonly used method--telephone and mass dissemination, and it included the government-imposed, the OMB-imposed, concept of consolidation. It was recommended that the FSS of the future be located at, but not in, air route traffic control centers. Leesburg is a crossbreed, because it is actually in the center. That was an economic move to get the thing going as fast as possible. Collocating with centers would put the two FAA systems that General Aviation uses most, the ATC System and FSS System, in a better position to coordinate and cooperate

in sharing information and facilities. The most significant of the recommendations of the general aviation organizations was the development of an operational prototype FSS at the Washington Air Route Traffic Control Center site at Leesburg, Virginia. This prototype would prove the concepts of automation, consolidation, and collocation. Together with information gained from the ongoing operational tests of automated equipment, AWANS in Atlanta, this would arm FAA with experience to improve the system in the near future.

With regard to that operational test at Leesburg, the FAA has procrastinated, they've studied, they've researched, they've failed to pare away the unrelated functions. They have made unannounced changes in the program, they've thrown up one excuse after another for failing to execute the test on a timely basis. It is still dragging along at a slow pace. We think that is one thing that has to be completed; we need that evaluation finished.

Now in late 1974 and early 1975, the general aviation organizations gained general acceptance from FAA top officials on a majority of the recommendations. One agreement was that Leesburg prototype. FAA top management agreed that the time for studying the FSS problem was past. Apparently the latter thought was not accepted by the lower echelons, since 2 years after the user recommendations, the FAA released an FSS "Masterplan." It is my understanding that there is even a further masterplan running around loose in the FAA now or between there and DOT. But, the masterplan and the associated FSS baseline specifications projected further delays in completing the program.

Recent remarks by certain government and nongovernment organizations indicated that the FAA program has full general aviation support. Those remarks are incorrect. AOPA believes that the FAA baseline specification is excessive in both functional capacity and cost. Further, the timetable which would provide relief to the deteriorated FSS situation in 10 to 15 years is totally unacceptable. The users projected completion in 5 to 6 years. Actually, the viewgraph that Bob Roche just used shows that this program would be running up to 1995. His baseline figures were starting at 1975. He gave me a start with the number of general aviation aircraft until I noticed the viewgraph showed it as 1975. That shows 20 years for completion of a program that the users estimated could be finished in 5 to 6 years from the time it was started.

Bob Roche also showed that by 1995 this program is going to come up with an annual savings of $200 million. That is the first time I have seen a program described by what it is going to save rather than what it is going to cost.

In summary, AOPA gives first priority to the Washington FSS operational prototype. This has to be completed. Priority No. 2 is for the implementation, system-wide, of various improvements as they prove themselves through operational testing. This may be a terrible thing to say, since I am in a hotbed of R&D, but, as far as we're concerned, the FSS problem does not require further R&D. It requires administration, installation, and operation.

Thank you.

QUESTION AND ANSWER - SESSION III

WEATHER AND FSS

MR. L. LANGWEIL

We're open for questions, please indicate your name and the organizations you represent, if any, on your questions.

MR. OMER BENN, (University of Illinois) - Question

I have two points that I would like to ask about: one, on the FSS briefings. One of the top complaints was that we hang on the telephone waiting. Why can't an automated system be plugged in? Along with giving you this big long spiel about your IFR, your aircraft number, where you're going, when you're leaving, and how much gas you are going to carry, why not give us the local weather information for that area and common routes on a recorded message while we're sitting there holding the telephone, cooling our heels. In this way we can pick up much of the weather information we need. I suspect that many pilots would get this information, hang up the phone, and go on their trip, and FAA would not get their count. And I wondered if any program like that has been considered?

MR. ROBERT ROCHE - Answer

We're considering that capability in the long term. First of all, it requires several technologies coming together. In communications, the voice switch, the telephone switch coming in that we have to implement at the stations; and secondly, with the voice-response capability that we are developing, we plan to have what we call a VRS specialist interactive, so when the pilot initially calls in, he would get such a recording and then have the ability to switch over to the specialist to complete the briefing.

MR. OMER BENN (University of Illinois) - Question

The second point I would like to make, goes back to training; and Mr. Sowar, I think, illustrated it beautifully in one slide that showed the number of accidents that occurred with crosswind landings. We have run into this in our training program. I want to preface it by saying that our FAA office has done a tremendous job working with us, we've had tremendous relations with them, and I don't feel that it is on that level that it's occurring. But any training accident that occurs--and this is one area in which teaching crosswinds illustrates it beautifully--I think goes back to an FAA philosophy, and I'm not sure even who to direct it to. But we have run into an incidence this summer, where, for training accidents, the FAA came in with the threat of violation, sending to legal departments and getting right on the back of the flight instructor for a mistake that was made.

Here is the thing that I particularly object to; your crosswind landings. I think probably most of those were caused by lack of proper training. It's an area that many instructors will avoid--heavy crosswind training--and they do it for the simple reason that if they make a mistake in it, they know the FAA is going to be on their back. The've got a threat of a possible violation and even under careless and reckless operation, you could stretch it and push these in. To me, those risks should be taken in a training program. The flight instructor should be assisted, but I don't feel he should be threatened with violations and possible fines, because what you're doing is driving him in a straight line down the middle of the road. He is not going to deviate, and I can't blame him a bit. Your training program is being hampered and is not being allowed to do the job as it should be done. I don't know whether you want to respond to that, Joe. I guess, technically, that isn't your area but I wanted to use you as a good illustration in how better training can reduce accidents.

MR. BOB ROCHE - Answer

Well, I totally agree with you on the fact that training can reduce accidents, and I also agree that crosswind landings should be taught. Now, from the R&D point of view, on those rules and "regs" in filing violations, that really goes over to the Flight Standards and some of the other people. I didn't know they were doing that, but as far as "should crosswind landings be taught?" as a pilot myself, I say "yes."

I just want to add one thing to the question that was asked first about waiting on the line. If the FSS system gets squared away the way it should be, there shouldn't be any waiting on the line. That's the thing we're trying to eliminate, and hopefully we will be successful.

MR. ROBERT WARNER (AOPA) - Question

On the remote altimeter settings in the last year, some of you may realize that TERPS have been changed, and in those locations that are in mountainous terrain. oftentimes an instrument approach is not approved when there is not a local altimeter setting. The only way this local altimeter setting is available oftentimes is through UNICOM, which, in most cases, is not available at night.

My question for Joe is a little more expansion on your discussion of remote altimeter--the experiment. How far away can a remote altimeter be located? Did you mention that the experiments were between when the report will be available and when the equipment will be available; and that people will be able to start purchasing it and will be able to use that equipment?

MR. JOE SOWAR - Answer

Distance, up to 30 to 50 miles, I don't think is any problem. It's a telephone-grade line that carries the information. The display, digital display, the small thing on the viewgraph, would be in the approach control stations so that they would be reading out the altimeter setting right there on this remote altimeter setting dial. That particular equipment is available. We are putting the digital displays in our control towers now. The use of the equipment as a remote system is not available or has not been approved yet, but our report will be out in December of this year.

Now, the equipment is rather expensive for the use we are talking about. The unit plus one display will run about $10,000. Again, I think Vic brought it up in his summary and it came up yesterday, that there's been a letter request that ADAP funds be made for purchasing weather equipment. Now this again is not my area, but I think a lot of these things on weather observations at small airports would really move ahead if that kind of legislation does take place.

(Unidentified Individual) - Question

As was indicated by the last speaker, we're rather impatient as to the timetable that FAA has established for flight service modernization. We were impatient with it in 1970, and we're still impatient with it. So, I'd like to ask Bob Roche a more near-term question, and ask if he could spend a minute or two describing the development as of late, the consolidation at the Leesburg prototype, and what progess is being made there?

MR. ROBERT ROCHE - Answer

At Leesburg, first of all, I would just like to run through the history on that. Originally, the announcement was made, by the Acting Administrator Jimmy Dow, in May 1975, of the selection of that location for a prototype and demonstration of the capabilities. We moved the Washington National FSS into the quarters that were prepared subsequent to that date in February of 1976. We had several FSSs scheduled to move in to complete the consolidation of Leesburg, and we were held up as Vic Kayne pointed out, due to pending legislation before Congress in the ADAP bill, which, in effect, authorized that consolidation. But it changed, or it identified the boundaries, and the two FSSs that were initially identified were outside of the boundaries of the Washington Center so we had to change our plans. But we did relocate 1 year later: Richmond into Leesburg in February 1977, and Charlottesville has been collocated and consolidated in July of this year. That completes the consolidation planned at this time. We are not planning any further consolidation, and in fact are continuing to take the data. Leesburg, as far as the FAA is concerned, is essentially complete, with the exception of finalizing some data collection, and we deem it to be a success.

MR. STANLEY TROTTER (University of Illinois) - Question

I'd like to go back to the first question that Mr. Benn asked; what I think might have been misunderstood. As I understood his question, he was asking, "Why not use the tape-recorded facilities that FSS now has, which tell you when the flight service agent answers to give your aircraft number, type, etc., to give an ATIS forecast for the local area?" I don't know what the data is on the number of people who use FSS facilities for local forecasts as opposed to enroute forecasts, but if you were to just sit there for a moment, waiting for the agent and you could get a local forecast, you might just hang up anyway. Those facilities are available because you have the tape recorded messages now.

MR. JOE SOWAR - Answer

Well, there's kind of an unfortunate history regarding this--it takes time to acquire equipment. In going through government procurement, we had initiated a procurement action, and it was delayed due to development problems. The FAA has now gone out, and the equipment they have is pretty old. We are due to improve the quality, and to get them back on the air, we are rebuilding and, at the same time, purchasing new taping equipment. So, we will see more capability in the very near future in terms of pre-recorded PATWAS kind of messages and the TWEB messages that we are implementing in more VOR's.

SESSION SUMMARY

MR. L. L. LANGWEIL

If there are no more questions, let me see if I can very briefly summarize what I think I heard here today. Regarding the first subject of wake vortex and wind shear, I didn't hear anything which indicates to me that the programs we're pursuing shouldn't be pursued with a high priority given to any safety-related program. As indicated, only the tip of the iceberg was covered in the presentation. I know that to be true. There were two areas that weren't covered because of time limitations. One is the surface wind monitoring system, SWIMS, which is presently being installed at six of our airports and which we intend to provide to others. The system will provide the first indication of wind shear on the approach zones of a runway. The second system is the Vortex Advisory System which is being installed in Chicago and which will be provided to other airports which have capacity problems. Capacity obviously is a problem to general aviation aircraft as they land at these high capacity airports with Air Carriers. Insofar as the weather presentation, from what I've heard here today, no one questions the R&D we're doing in the weather area; it should be continued and accelerated as we've indicated that we intend to do in FY78. There are a number of policy decisions regarding the use of ADAP funds for procurement of equipment. At the present time, these are under consideration in the upper management levels where such policy decisions are made. Regarding the last presentation of flight service stations, regardless of the merits of the arguments as to whether what we're doing is being done quickly enough or whether the general aviation community agrees or disagrees with our position, the one thing that comes through, very strongly, is the lack of communication between the general aviation users and the FAA upper management groups. I would strongly recommend that a comprehensive meeting be held to solve these problems and to get this communication going.

SESSION IV

AIR TRAFFIC CONTROL

Mr. David J. Sheftel, Director
FAA Systems Research and
Development Service

CHAIRMAN

Mr. Edward J. Malo, Chief
Airspace Regulations Branch
Airspace and Air Traffic Division
FAA Air Traffic Service

Mr. Ricardo Cassell
RNAV Project Officer,
Simulation and Analysis Division
FAA National Aviation Facilities
Experimental Center

Mr. William Horn
Manager of the Airspace/Air Traffic
Control Services for the National
Business Aircraft Association, Inc.

Mr. Frank Frisbie, Chief
Approach Landing Division
FAA Systems Research and
Development Service

Mr. Sieg Poritzky, Director
FAA Office of System
Engineering Management

Mr. John L. Baker
President of Aircraft Owners and
Operators Association, Former
Assistant Administrator for
General Aviation at FAA

Mr. John H. Winant
President of National Business Aircraft
Association, Chairman of NASA's
Advisory Committee on the Aviation
Safety Reporting

ATC SESSION INTRODUCTION

MR. DAVID J. SHEFTEL

I am Dave Sheftel. My function in the FAA is Director of Systems Research and Development Service which is the arm of the research and development organization that is concerned mainly with hardware development. The prime topic as you can see from the agenda is air traffic control with the emphasis on general aviation aspects. The topics include area navigation (RNAV), the microwave landing system (MLS), and also the general subject of the future evolving air traffic control system.

Some of the issues that we expect to be discussed regarding RNAV concern the implementation strategy. This includes questions regarding how it should be implemented (by user initiatives or by government initiatives acting catalysts). My opinion is RNAV is no longer an R&D program. There are some R&D activities, but RNAV has been developed for a long time and it's strictly an implementation/ operational issue. This will come under some discussion, I am sure, including the questions of whether it pays off, what is in it for the user, and what is in it for the government.

With respect to the microwave landing system subject, as you know, it is a very visible issue and an international issue. I would like to make the observation that while MLS was a technical issue being assessed by ICAO international experts, the United States system was winning quite clearly. More recently, MLS has become a subject for lobbyists and duels through the media. Parochial misrepresentations seem to be prevalent in attempts to cast doubt on the findings of AWOP VI.

With respect to the future evolving system, you will be hearing about that subject from Mr. Poritzsky. From the forecasts that you have heard a number of times predicting more than four times increase in general aviation operations by the late 1990s and more than six times increase in enroute IFR during the same time period, it is apparent that this growing demand cannot be met without system change. Unacceptable staffing required to run the system, unacceptable costs of maintaining and operating, and very probably unacceptable safety would result if we try to accommodate growth without change. There are some penalties inherent in the required changes. It will cost more for everybody to operate in a system where aircraft operate closer to each other.

AREA NAVIGATION FOR GENERAL AVIATION

DAVID SHEFTEL

"I'd like to introduce the first speaker who is Ed Malo. Ed is in the Aerospace and Air Traffic Rules Division of FAA's Air Traffic Service (ATS)".

MR. ED. MALO

Ed Hanlon was supposed to give this talk, and I am sure if he showed up, he would have had a lot of nice viewgraphs. I have been associated with area navigation probably for the last 8 or 9 years. I personally see a great interest in area navigation throughout the aviation community. Unfortunately, we haven't been able to put in routes that seem to be acceptable to the users. Maybe the first thing I should do is discuss a little background on how we got to where we are with our present high altitude RNAV system.

In early 1970, we began planning a high altitude route structure that is above FL 180 and we thought this was the area where we would get the most usage of area navigation. We selected major hubs that exchanged 20 or more IFR aircraft on a peak day and connected these hubs with great circle routes. We also selected lower density hubs and connected them with single routes. On the high density routes we established dual line air routes and on the lower density hubs we established single routes. We connected them with great circle routes. We did not give any consideration to special use airspace, location of NAVAIDS, and location of radar sites. We flight checked all these routes, at quite a considerable expense, by flight inspection aircraft and eventually, after coordination with the various ATC facilities and also with some of the users, published approximately 165 high altitude RNAV route segments. Now over the years, since the early 1970's, these routes have essentially remained the same way that they were when we first introduced them. We made some slight modifications for charting reasons and had several of the users request specific routes. If we could accommodate them, we would put those routes in. However, essentially in the last 6-1/2 years, the routes have remained the same.

In early 1976, we decided to conduct a survey of our 250 domestic air route traffic control centers, to find out how these routes were being used or even if they were being used. During the 6-day survey, these were 6-consecutive days, but not the same days at each center, we found that there were only a total of 185 RNAV flight plans filed in the high altitude route structure. One hundred and twenty-five were filed by air carriers, 3 by military operators, and 56 by General Aviation aircraft. That was above FL 180. Now some of the reasons that at least we feel that pilots don't fly our published routes are; one, the routes don't go where the pilots want to go; two, even though we tried to develop the routes as great circle tracks between the two terminals, they

really were not the best weather route on any particular day, it wasn't the least time track, or it wasn't where the pilot wanted to fly. Again, for operators who had computers to do their flight planning, either the routes weren't programmed into the computer or the computer just wasn't kicking out the routes. Therefore, the pilots weren't flying, and I think probably more important, pilots who were operating in a high altitude route structure found that they could go direct once they reach their cruising level, just by asking for a direct route and the controller approving it and monitoring his route of flight with radar. I guess what I am saying is that the routes, at least those we presently have published, are not being used and people are doing something different. We really don't have a real good handle on what they are doing. We took a look at the charts they were publishing and the direct operating cost last year to the FAA, for publishing the National Ocean Survey (NOS) high altitude RNAV charts, which totaled approximately $143,000. NOS told us that they publish about 2,300 sets of RNAV charts, that's 9 charts, and only 128 were purchased by users other than the FAA.

In January of this year we made a presentation to the former FAA Administrator, Dr. McLucas on where we are and where we think we ought to go, Dr. McLucas issued an RNAV policy statement that indicated that the FAA recognizes the advantage that RNAV offers to both the ATC system and the operator and will pursue a 2-part program leading to the ultimate objective of an RNAV-based system. The policy statement also said, and I quote, "Mandatory carriage of RNAV avionics as a condition to participate in the ATC system is not envisioned in the near future." Dr. McLucas' RNAV policy statement also indicated that the FAA would eliminate RNAV routes that do not respond to user requirements. The FAA will establish RNAV routes, SIDS, STARS, on a case-by-case basis to meet user requirements. Thirdly, develop a national waypoint system to facilitate pilots selection of direct routes. Fourth, develop a continuing program to educate pilots, air traffic controllers, flight service station specialists, and flight standards specialists about RNAV and its capabilities. That is probably one of the hardest nuts to crack that we have. We are going to do it, and we tried to do it in the past, and we issued an RNAV film. We issued an awful lot of material to the field. Unfortunately, the amount of pilots that are operating on RNAV equipment on the whole, are so few that the air traffic control and the flight service station specialist does not get exposed to it often enough to really be up to date on RNAV; however, we will continue to stress and to promote the establishment of RNAV approaches at non-instrumented airports and develop and promulgate RNAV avionic minimum performance standards.

Now all of the proposed actions that I've mentioned are considered to be near-term in that hopefully within the next year or year and a half, we will have completed all those actions. We have asked some of the user organizations, and I think Bill will talk about that a little bit later, to give us their input as to where we ought to go with RNAV. We've had some very good suggestions and recommendations from several of the organizations. Between now and the end of the year we are proposing to delete a large majority of the presently designated high altitude RNAV routes, and of course this was done through rule-making action which requires us to issue notices of proposed rule making (NPRM's)

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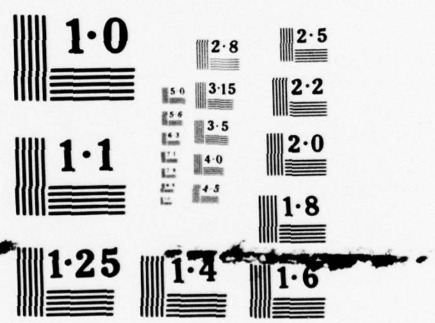


NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

just like we did when we established the routes. We planned probably to issue somewhere between 10 and 12 NPRM's. By the middle of next year we hope that we will have deleted those that aren't being used and will have established some new ones if we have enough user requirements.

In the controller training area, as part of the recurring training, controllers do get a little exposure to area navigation and hopefully in the next year we will increase that exposure.

In the Flight Standards area, flight standards personnel are exploring the possibility of establishing additional RNAV waypoints that can be used in conjunction with standard instrument approach procedures. We have not really firmed that program up yet to any great extent but there is a lot of consideration being given to putting RNAV waypoints, at the outer marker of ILS's for instance.

We conducted a survey on: "What's the best way to show terrain on enroute low altitude charts." Several months ago we, the Cartographic Division, received an awful lot of comments on their experimental terrain concept and it seems that this probably would be a good feature for direct RNAV route flight planning. You have a much better idea of what the terrain is in any particular area.

Now there is one other part of the policy statement, that Dr. McLucas issued, which says that the FAA will undertake a long-range effort to develop a master enroute and terminal RNAV route design which hopefully would bridge the gap between today's structure and a future RNAV structure. The only thing that hasn't been decided yet is the time frame and the amount of funds that would be allocated during that time frame.

I guess in closing I would like to say that I, personally, am an advocate of area navigation. I have been. We tried to develop an RNAV route structure that didn't seem to fly. I think that if anybody has any RNAV requirements, they should contact the local FAA ATC facility, or the regional office, or our office; we do everything we can to satisfy your RNAV requirements.

AREA NAVIGATION FOR GENERAL AVIATION
---MINIMUM REQUIREMENTS FOR EQUIPMENT

MR. DAVID SHEFTEL

You've heard from the operational side of FAA on the subject of RNAV and the next speaker, Ricardo Cassell, is the Program Officer for RNAV. He works here at NAFEC, and his subject is the "minimum requirements for the equipment." This is an R&D program in support of the overall RNAV subject.

MR. RICARDO CASSELL

I would like to describe briefly the objectives of the RNAV Avionics Standards Program, give you a little additional background on the program, talk about the need for avionic standards; and tell you what we are doing, have done, and will continue to do in the very near future.

NAFEC has been assigned a major role of responsibility for Area Navigation or RNAV Avionic Standards development. The objective of this program as shown here, is the development and coordination of avionic standards for Instrument Flight Rules operations, including minimum performance standards, and minimum operational characteristics for both 2-dimensional, and 3-dimensional Area Navigation Systems, figure 4-1. For those of you who may not be familiar with the terms 2-dimensional RNAV (2-D RNAV), and 3-dimensional (3-D) RNAV, let me spend just a moment to explain what is meant by these expressions. RNAV airborne equipment provides a means by which aircraft flight may be conducted on any desired course within the coverage of station-reference navigational signals or within the limits of self-contained system capabilities. As shown in figure 4-2, the RNAV avionics system provides navigational guidance between waypoints X and Y. Waypoint X is defined to the RNAV system as some given distance and radial of VORTAC ALPHA or "A". Waypoint Y, is defined similarly, referenced to VORTAC BRAVO or "B". The RNAV route between the two waypoints is more or less independent of the actual location of the VORTACs that support these waypoints, thus providing a more flexible and frequently more direct routing capability than that provided by flights on radials between VORs or VORTACs.

These illustrations essentially depict RNAV systems which use waypoints based on range and azimuth from VORTACs. However, there are other types of systems which are self-contained and provide navigational guidance between waypoints that may be identified by latitude and longitude rather than by reference to a VORTAC. Three-D RNAV, as shown in figure 4-3, implies exactly what it says. It uses a capability in both horizontal and vertical planes, thereby adding descent and climb guidance to horizontal track guidance. The climb or descent vertical angle can be selected to insure attaining a required altitude at any given point. In addition, the point at which the descent or climb will be started or completed can be modified through an along-track offset.

In 1969, the Radio Commission for Aeronautics or RTCA, published a document, DO 140, that described the minimum operational characteristics for 2-D RNAV systems, figure 4-4. This was later followed by DO 152, which pertained to 3-D RNAV systems. The Federal Aviation Administration has published advisory circulars AC90-45 followed by AC90-45A, which provide guidelines for implementation of 2-D RNAV within the U.S. National Airspace System. I should mention in passing that AC90-45A is now being updated based on more current information. In addition, in February of 1973, a report by an RNAV Task Force comprised of FAA and industry representatives prepared a report which was published by the FAA. This report, "Application of Area Navigation in the National Airspace System," set forth concepts for the implementation of RNAV and recommended additional system requirements based on those concepts.

In January of 1977, the FAA published an RNAV policy statement which was previously referred to. This policy statement was strongly influenced by the results of a number of studies conducted or supported by NAFEC. These studies examined, evaluated, and revised in some areas the concepts set forth in the RNAV task force report. The results of these studies were used to determine ATC System and System user payoffs which can be made available through the use of RNAV. The FAA policy statement established an action plan as previously mentioned, for implementation of RNAV. The plan provided for both short-term and long-term efforts, but it is worth mentioning again, that this policy statement did not require RNAV as a cost of entry into the system. It is, and will remain for the forseeable future, your option as a user of the system, whether to use RNAV, or equip a particular aircraft with RNAV, or not.

I just mentioned the RNAV task force report. There are certain avionics requirements that were recommended in that report. To you in general aviation, some of these task force recommendations for minimum operational characteristics may be of particular interest (figure 4-5). Let me stress that these do not represent FAA or industry standards. They are presented here only to give you a little fuller background on some of the work that has gone before. There are, in fact, a number of these requirements or assumed requirements which our data does not really support at this time. For example, the RNAV taskforce recommended navigational accuracies compatible with the recommendation that route widths (RNAV route widths), be reduced to constant route widths of 2-1/2 and 1-1/2 miles for enroute and terminal area operations. Such a recommendation immediately raises the question, "Are these reduced route widths really required, and if so, can the needed accuracies be achieved, and, at what cost?" These RNAV task force minimum operational characteristic recommendations raise a number of issues to be considered, but let me stress again, they are simply that, they are issues; they do not constitute standards. It is the FAA's intention to develop minimum standards that meet instrument flight rule navigation system requirements but do not place RNAV avionic systems beyond the price range of the general aviation system user.

While the RNAV task force report provides an input to the development of these avionic standards, much work has been done, since 1973, when the task force report was published. Other sources provide inputs that qualify, modify, and expand upon this earlier input, figure 4-6. There have been extensive studies

conducted of area navigation enroute, and terminal area structures, including both fast-time, and real-time simulations which have provided useful information in the development of standards. Existing RNAV equipment standards have also been of value and provided a basis to build upon. Most important, new data are now being made available through flight test and cockpit simulations for validation of system performance and requirements. All these will contribute to the development of standards for coordination with the ATC system user.

RNAV provides potential benefits to both the ATC system user and the ATC system itself. As a result, the FAA is interested in the development of avionic standards which will be compatible with the ATC system and which will permit realization of these benefits for all segments of the ATC system and of course the ATC system itself, figure 4-7. The FAA has conducted a number of studies, analyses, and simulations that identified meaningful potential advantages for RNAV. For the system user, these are fuel savings, and time savings, which translate to dollar savings, improved airport access, route flexibility, and return of navigation to the cockpit. From the ATC system standpoint, payoffs are found in controller workload reductions in such areas as communications time and count, and the number of control instructions issued. These reductions in controller workload provide a potential for increased controller productivity and ATC system capacity increases as well. In addition, the use of RNAV can represent cost reductions to the FAA in NAVAID costs.

In order to achieve these benefits, one of the necessary steps is the development of avionic standards compatible with the ATC system environment in which RNAV provides not only a navigational system for the pilot but a control tool for the controller, since it has been learned during our simulations and tests, that cockpit navigation using RNAV can be advantageously substituted for radar vectors in many cases, figure 4-8. In order for RNAV to be useful in the ATC environment, it is necessary that RNAV functions, regardless of the type of avionics system involved, result in like and predictable RNAV maneuver performance. This means that minimum functional capabilities and accuracy requirements must be established, error budgets analyzed, and certification requirements determined. It also means that minimum standards---and I stress the word "minimum" in this case---because it sounds like I may be frightening you a bit, minimum standards must not impose unrealistic requirements on the system which would needlessly inflate the cost of the RNAV avionics systems for those users that wish to equip with RNAV. You in general aviation represent a large segment of these potential users.

A series of flight tests and cockpit simulation tests have been, and are being conducted to determine what these minimum avionic standards should be (figure 4-9). Pilots of various levels of experience are used in these tests as test subjects. Different avionic systems have been used in these and other field tests which are not shown in figure 4-9. These tests are directed at examining a series of issues, among which are those listed here. Flight technical error measurements have been made in flight tests as well as simulation tests using general aviation trainer cockpit simulators. Waypoint storage requirements have similarly been tested. Turn anticipation, and ability to fly parallel offsets

have been tested both in flight tests and simulation. Course selection problems and accuracy are being evaluated. And slant-range error data and total system requirements are being developed.

So where do we stand today? Data collection for all flight tests and cockpit simulation tests are scheduled to be completed next month, figure 4-10. The data from all these tests should be analyzed by November, and draft or data reports available for initial coordination with the users of the system by December of this year. The final reports, unfortunately, should generally be published in March or April of 1978. However, it is our hope to initiate coordination with the ATC system users this December so that we can, hopefully, by June 1978, complete the coordination cycle in the development of avionic standards.

I thank you for this opportunity to speak to you, and I thank you for your attention.

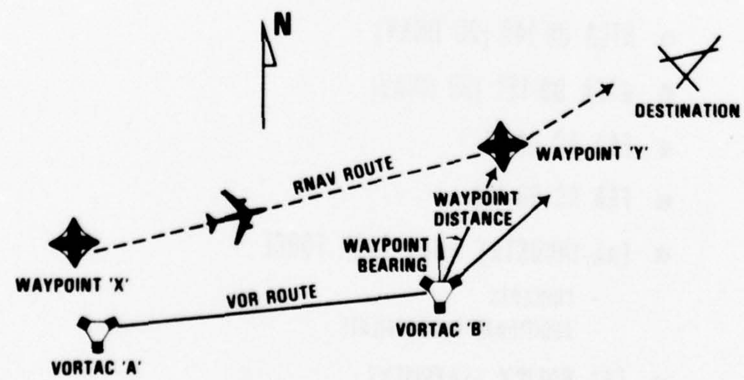
AREA NAVIGATION
(RNAV)
AVIONICS STANDARDS PROGRAM

OBJECTIVE:

DEVELOP & COORDINATE 2D AND 3D RNAV AVIONICS STANDARDS INCLUDING MINIMUM PERFORMANCE STANDARDS AND MINIMUM OPERATIONAL CHARACTERISTICS.

FIGURE 4-1

AREA NAVIGATION
2D RNAV



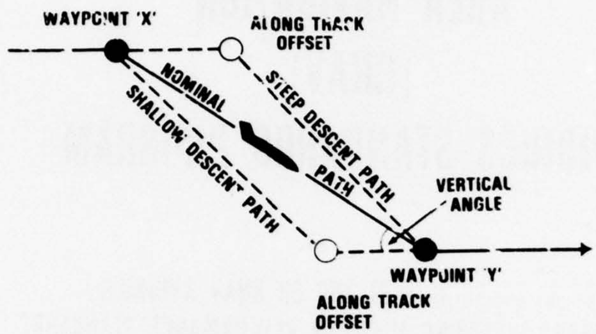
AREA NAVIGATION (RNAV)

A method of navigation that permits aircraft operations on any desired course within the coverage of station referenced navigation signals or within the limits of self-contained system capability.

2D RNAV utilizes capabilities in the horizontal plane only.

FIGURE 4-2

AREA NAVIGATION
3D RNAV (VNAV)



AREA NAVIGATION (RNAV)

A method of navigation that permits aircraft operations on any desired course within the coverage of station referenced navigation signals or within the limits of self contained system capability.

3D RNAV (VNAV) utilizes capabilities in the horizontal and vertical plane.

FIGURE 4-3

BACKGROUND

- **RTCA DO-140 (2D RNAV)**
- **RTCA DO-152 (3D RNAV)**
- **FAA AC 90-45**
- **FAA AC 90-45A**
- **FAA/INDUSTRY RNAV TASK FORCE**
  - **CONCEPTS**
  - **ADDITIONAL REQUIREMENTS**
- **FAA POLICY STATEMENT**
  - **REVISED CONCEPTS**
  - **SYSTEM/USER PAYOFFS**
  - **ACTION PLAN**
    - **SHORT TERM**
    - **LONG TERM**
    - **AVIONICS STANDARDS**

FIGURE 4-4

FAA/INDUSTRY RNAV TASK FORCE
MINIMUM OPERATIONAL CHARACTERISTICS

- NAVIGATION ACCURACY
  - ROUTE WIDTHS
- SLANT RANGE CORRECTION AT & ABOVE FL180
- NAVIGATION GUIDANCE DISPLAY
- PARALLEL OFFSET
  - PARALLELING IN TURNS
- TURN ANTICIPATION
  - HORIZONTAL
  - VERTICAL
- WAYPOINT INSERTION/STORAGE
  - 6 WAYPOINTS (2D)
  - 10 WAYPOINTS (3D)
- IMPROMPTU WAYPOINT SELECTION/ENTRY
  - DIRECT TO WAYPOINT
- WARNING INDICATORS
- INPUT CORRECTNESS CHECK

FIGURE 4-5

RNAV AVIONICS STANDARDS

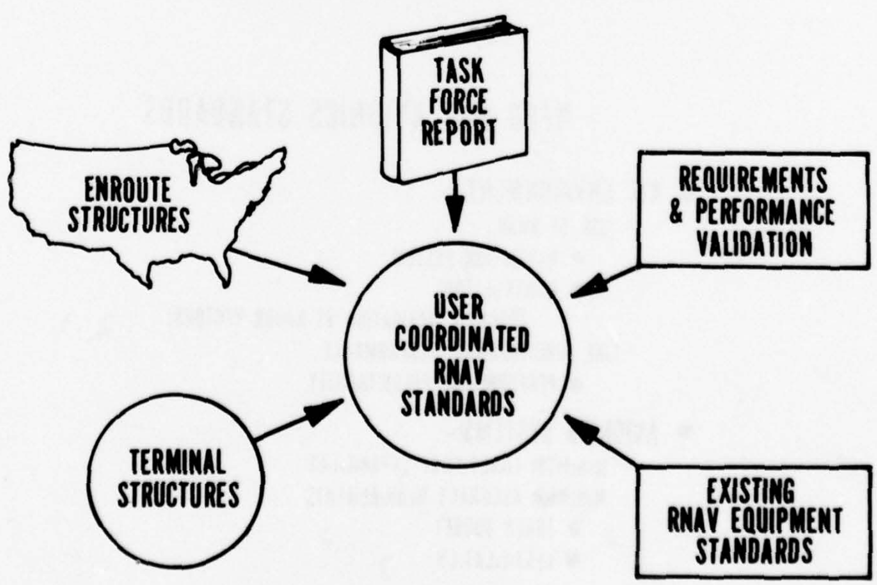


FIGURE 4-6

WHY
RNAV AVIONICS STANDARDS PROGRAM

- RNAV PROVIDES POTENTIAL BENEFITS TO THE ATC SYSTEM USER AND TO THE ACT SYSTEM
  - ENROUTE ROUTE STRUCTURE DESIGN STUDIES ANALYSIS
  - TERMINAL ROUTE STRUCTURE DESIGN STUDIES ANALYSIS
  - ENROUTE REAL TIME ACT SIMULATION
  - TERMINAL REAL TIME ATC SIMULATIONS
  - PAYOFF ANALYSIS
    - FUEL SAVINGS
    - TIME SAVINGS
    - DOLLAR SAVINGS
    - AIRPORT ACCESS
    - ROUTE FLEXIBILITY
    - COCKPIT NAVIGATION
      - CONTROLLER WORKLOAD REDUCTION
      - POTENTIAL PRODUCTIVITY INCREASE
      - SYSTEM CAPACITY INCREASE
      - NAVAID COST REDUCTION

FIGURE 4-7

NEED FOR AVIONICS STANDARDS

- ATC ENVIRONMENT
  - USE OF RNAV
    - NAVIGATION SYSTEM
    - CONTROL TOOL
      (COCKPIT NAVIGATION VS RADAR VECTORS)
  - LIKE FUNCTIONS-LIKE PERFORMANCE
    - PERFORMANCE PREDICTABILITY
- AVIONICS SYSTEMS
  - MINIMUM FUNCTIONAL CAPABILITIES
  - MINIMUM ACCURACY REQUIREMENTS
    - ERROR BUDGET
    - CERTIFICATION

FIGURE 4-8

RNAV AVIONICS TESTS

	FLIGHT TESTS				SIMULATION TESTS		
	AC-680 AIR DATA	G-1 EDO	G-1 COLLINS	AC-500 KING	GAT-II MINI-COMP.	GAT-II KING	GAT-II EDO
FLIGHT TECHNICAL ERROR	X	X	X	X	X	X	X
WAYPOINT STORAGE	1,2,3 WAYPOINT	1-20 WAYPOINT		1 WAYPOINT	1,2,3 WAYPOINT	1 WAYPOINT	1-20 WAYPOINT
ANTICIPATION	PROCEDURAL	AIDED	AUTO	PROCEDURAL	AIDED & PROCEDURAL	PROCEDURAL	AIDED
PARALLEL OFFSET	PROCEDURAL	X	X	PROCEDURAL	PROCEDURAL	PROCEDURAL	X
COURSE SELECTION	OBS CARD	OBS CARD	DIGITAL	OBS CARD	DIGITAL	OBS CARD	DIGITAL
SLANT RANGE ERROR	X	X		X			
ACCURACY	X	X	X	X	X	X	X

FIGURE 4-9

RNAV AVIONICS PROGRAM SCHEDULE

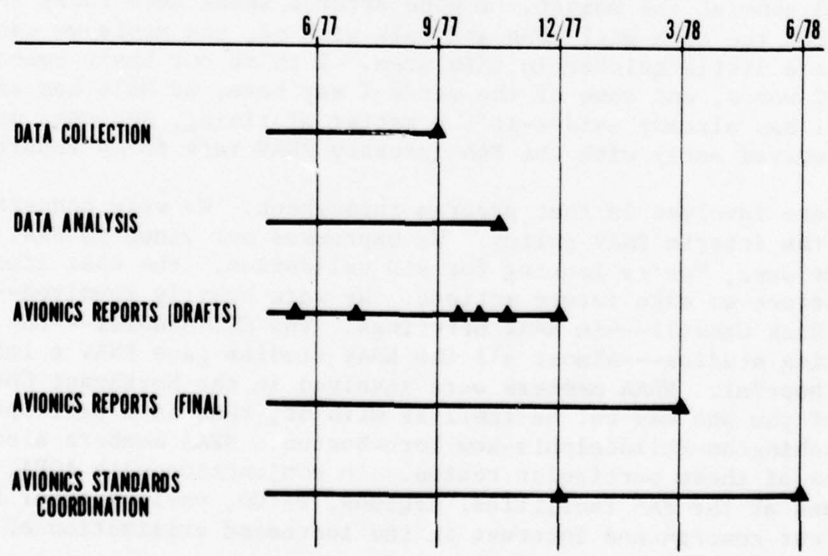


FIGURE 4-10

A GENERAL AVIATION USER VIEW ON RESPONSE TO AREA NAVIGATION

MR. DAVID SHEFTEL

We're especially interested in hearing a viewpoint from the next spearker, not only because he represents the NBAA, but also because of Bill Horn's extensive experience both inside and outside the Government. Bill Horn is the Manager of the Airspace and Air Traffic Services for the NBAA.

MR. WILLIAM (BILL) HORN

I am happy to be here this morning, gentlemen, as a representative of a user organization of the NAS system. A very complex subject, RNAV, and we cannot get two people to agree on which way to go. I'll just cover some general areas this morning. I'll start off with a quote from a previous Administrator, go through a litany of things we in NBAA and some of the other alphabet organizations have done over the years, which show, I believe, that we have a reasonable interest in this subject; cover a little bit about the boxes we have in the air machine, and take a quick look at what tomorrow is going to bring.

I quote from an interview that John McLucas gave: McLucas said he was able to forge ahead with some good works for General Aviation, notably in area navigation. "I got everybody to take the oath. We are going to go ahead with the RNAV concept. And if they do it, they claim they're going to do it in 3 or 4 years time, we'll be in good shape on that," he said.

I've spent some time wandering through FAA, looking for any of the oath takers; I have found none at the moment. I hope after I speak here today those people who have taken the oath will come and talk with me, and maybe we can work with them to move a little quicker in this area. I think our basic concern is there are a lot of words, and some of the words I say here, Ed Malo has said, and Rick Cassell has already said---it's a matter of timing, actions, movement. NBAA was involved early with the FAA industry RNAV task force report of 1973.

We had members involved in that program throughout. We were concerned and upset with the interim RNAV policy. We expressed our views to FAA. Answers at that time were, "we're looking for R&D validation," the cost studies that are necessary before we make future motions. We were heavily involved---Mike Brandewie, Rick Cassell---in RNAV briefings. The CTI studies---the payoff in the supporting studies---almost all the RNAV studies gave RNAV a lot of pluses. So we were hopeful. NBAA members were involved in the Northeast Corridor Study. For those of you who may not be familiar with it, this is a helicopter RNAV routing, Washington-Philadelphia-New York-Boston. NBAA members also flew flightchecks of these particular routes. In conjunction with AOPA, we have made speeches at the FAA facilities, Regions, PATCO, various other forums, evidencing our concern and interest in the increased utilization of RNAV.

At our NBAA convention in 1976, navigation was covered in a major symposium. Bob Wedan, from SRDS, was the FAA representative. We worked with the FAA in trying to have them update their interim RNAV policy; and also for those of you who may or may not be aware, in late 1976, they formed an Area Navigation RNAV Coordinating Committee--and there are about 10 chiefs in that particular group. The chairperson is Mr. Alvarez. I am not sure that group has met very often, or has taken any specific, positive actions to move RNAV any faster.

We were reasonably happy when FAA put out an RNAV policy statment in January of this year. We correspond with our members through "NBAA Action Bulletins," when we want our people to respond and get into the act. Immediately after that FAA policy statement was released, we put out our action bulletin, we asked for volunteers to get more involved in the RNAV program, and we sent them a copy of that particular bulletin. We also sent the same bulletin to the appropriate people within the FAA, and also to PATCO representatives. In March of this year---and it relates to something Ed Malo said earlier---we got a questionnaire or a question, really, from Bill Broadwater, containing a listing of RNAV routes and asking for suggestions on retention or establishment of those which would better accommodate our requirements. We thought that was a rather difficult thing to answer in one letter; so we answered back and said we were working the problem, we would come back, hopefully, with a little more detail. We also have under the jurisdiction of our AS/ATC committee, about 35 NBAA members who are volunteers and that are allied with all of the FAA regions. These members concentrate on ATC problems. Under that umbrella, we established an RNAV subcommittee, whose chairman is Myron Collier, of the CYCOPS Corporation empire---Detroit Steel Division---in Mansfield, Ohio. We have also, recently formed a helicopter committee which is also working, obviously, in the RNAV area. We held a meeting, the first meeting of this particular group, on the 12th and 13th of May of this year. The second day of our meeting we had FAA representatives present. I have here a listing of that group and it is probably over 30 people that are part of that subcommittee; all of them obviously could not make that particular meeting. Whatever literature we have generated, we have sent to these people. So they are in the loop and are ready to move as we so indicate.

As I said earlier, RNAV is a very controversial area and subject. There are many areas we can agree fairly easily on, but, there are others where I think it is going to be years before we get anybody to say, "Yeah! This is the way to go---accuracies, coverage of VOR's, turn radiuses." We addressed the whole range of questions in that meeting, and we had operators from single-engine planes up to the biggest birds we have in our fleet---a real good cross-section. To get a feel for how FAA would react to some user inputs, we tried to get at least a half dozen areas that we could generally agree upon, forward that to the FAA and see what kind of reaction we would get back. And I'll just, in general, go over these very quickly. RNAV usage; we feel, felt then, feel now, that FAA's statistics are woefully inadequate in realizing how many people out there in the real world are actually flying RNAV. As Ed (Malo) said, we're not flying those routes, those lines that they drew, because they don't go where we want to go. But they're being flown today, and have been flown for some period of time. We also tried to get across to them that an awful lot of

airplanes that are being built today are having RNAV equipment put into them. There are more and more black boxes out there in the real world, and more and more people will utilize RNAV if they're sure they can get clearance when they ask for it. And we think the pilot-controller relationship can be improved. We think we can help the controller.

In the area of education, which Ed feels is a tremendously difficult area, we don't have the same feeling. We recommended and suggested that FAA establish a small RNAV training team, with three or four members, people who know what the game is all about, to brief the various regions, the controllers and the specialists, on user requirements and present an anticipated use of RNAV equipment. Both AOPA and NBAA said, if and when you do that, we will do everything we can to supplement your training team with manufacturers who are building the boxes and our users who are out there using the equipment. Just ask us, and we'll have them there, if at all possible. We have recommended to our members that they give controllers, whenever and wherever possible, an explanation on how RNAV works and how it can help them. We have asked for increased emphasis on RNAV studies in the FAA Academy's prospectus of courses. We've asked that the controllers handbook and 7110 insure that adequate RNAV guidance is provided to the controllers and the specialists, and that the AIM include updated information on the usage of RNAV. Suffix "F" is utilized in the flight plan to identify the fact that the operator has RNAV equipment onboard the airplane. It doesn't necessarily mean that you are going to use the equipment on that particular flight. We suggested as an interim procedure, that whenever the pilot indicates that he will use an RNAV piece of equipment for an RNAV flight, he so designate it in the flight plan and those remarks be transmitted to the appropriate and proper control agencies.

In discussing the equipments, we felt that they fell into two basic operational categories: course-line computer type, and the VORTAC-oriented type which requires a fairly considerable cockpit workload if you change the aircraft's route of flight in midstream. The pilot must start flipping charts and maps to determine how he is going to get from point zero to point Y. With the self-contained, or more sophisticated equipment (INS and VLF) the workload is simple and is a matter of hitting a couple of buttons and the man is on his way. We suggested that at least for a while two suffixes be listed so that the controller would have a feel for the equipment that was on the airplane and the workload required of the pilot. Basically, we feel there is no practical use for the high-altitude RNAV routes. We think the random direct capability is there and recognize that the controller obviously has a concern as to whether the pilot knows exactly where he is. We think the sophistications of black boxes today tells the pilot where he is as accurately as the radar box tells the controller where the pilot is. So we think direct line usage should be increased. Some of our strongest advocates of flying RNAV have said in some cases they can't get their pilots to use it because, in the flight planning arena, they have to go through five or six separate and different charts to figure out how to get where they are going. So we have recommended and suggested some simplifications, particularly in flight planning, with respect to the initial on-the-ground portion of the charts. One or two of our people who are quite interested in this area have developed certain

suggestions and those suggestions were forwarded to FAA. We also realize that in the transition from high altitude to the terminal area, in many areas, the local ATC people have their predetermined ways of how they are going to handle traffic. In some areas we have gone to the four-post system, but the itinerant pilot, in particular, does not know where these particular locations are. We think if we could get waypoints at those particular spots, that pilot would be navigating to positions that the controller wants him to go for. And we would like that to be available.

Ed Malo mentioned one of these on the instrument approach procedures and charts, and indicated that, for non-RNAV air approach procedures, waypoints should be designated and depicted at the final approach fix, or, in the case of an ILS, at the outer marker. If there is no final approach fix, then the primary facility on which the approach is based, the VOR or NDB. For airports with no approved instrument approach procedure, a waypoint at the airport center should be established. Such a waypoint could provide direction and distance to the airport for visual landing.

Very briefly those are some of the comments that we forwarded in our last letter. In addition, at the last PATCO convention in Hollywood, Florida, I was able to speak to their safety committee, about 15 or 20 controllers. I specifically asked them to update themselves on the latest RNAV capability, what the equipment can and cannot do. I told them we felt that the pilot-controller relationship could be improved and we could help each other. I made some of the same recommendations to them that I have discussed here that we have forwarded to the FAA. Mr. McIntosh, NBAA's Director of Operational Services, at a congressional hearing before the Science and Technology Sub-committee on Transportation, Aviation and Weather on June 16, 1977 , made comments relating to distributive management versus complete ground control; in essence, to utilization of equipment in an airplane to help move airplanes in the airspace we have available to us in this country. So we feel that we have given FAA, many parts of FAA, a feel for what our requirements are. It is obvious we haven't pinpointed each and every one of them. But, I think we got across to them, hopefully, that we are interested in using RNAV equipment, particularly the group that I represent. We have people operating out of many, many airports in this country, many of which have no approach capabilities. We foresee the use of RNAV to a point in space for continuation for a VFR approach. We think it has a tremendous amount of capability.

I said I would mention a little bit about equipment. When we went through the exercise in RNAV, we put out the survey to get a determination of what boxes operators had in their airplanes. Almost in the same time frame, we were involved in a minimum navigation performance study for airplanes flying over the North Atlantic. That survey was also used. We find that we have a tremendous amount of equipment in the business aircraft fleet, not only in quantity but variety as well. We have everything from single-waypoint equipment to the boxes that have your entire ATC system in their computer storage. If you look at the manuals, the salesbooks, you'll find that almost every vendor, if you go through our fleet, has his equipment in some or one of our airplanes. The boxes are out there and they are obviously not being used as much as people would like to use them. We would hope that the movement by FAA would be a

little faster in the future. We're concerned about the ad hoc nature of what is happening today. As I stand in front of you, we have members that have already designed RNAV routes. Those RNAV routes sit today in one of your 9020 ARTCC computers, and they're being used by those members. If it is an ad hoc exercise, it exists because of the drive and determination of that particular individual or group of individuals. We also have a number of our people that have RNAV approaches for specific and particular airports which are within the chart structure today. Again, ad hoc procedures. We would like a little more coalescing so that we all go in the same direction a little bit faster.

The last note I have here is future actions. Again I repeat a little bit of what I've said earlier, I'm looking very carefully for the oath takers. I would like to talk to those gentlemen who think that RNAV has a future. There's not one individual that knows all about this particular subject. It's complex, but we think within the structure of NBAA, we can get the people that are knowledgeable to sit down with you, to work with you, to assist you in anyway possible. We talk about fuel savings and time savings. We think this is one of the most important ways to do that for our membership and the general aviation community.

MR. DAVID J. SHEFTEL

The next speaker for this session is Mr. Frank Frisbie who is Chief of the Approach Landing Division. Frank will describe the Small Community MLS for general aviation users.

MR. FRANK L. FRISBIE

I would like to start by telling you a little about the broad scope of the National MLS Program and then focus on general aviation interests. It is a national program involving DOD, NASA and DOT, figure 4-11. On your visit here to NAFEC, you may see some DOD aircraft, fixed wing, and helicopters, flying on the MLS system.

Just going back a second to "why MLS?" I think, figure 4-12, all of you probably ask that question from time to time. We have catalogued here the reasons that started us off. I think they are pretty much embodied in the first statement which indicates that there was a set of operational requirements developed, not only here, but internationally which ILS could not meet. That added to the litany of the problems, some large and some small, that ILS has inherently, and is responsible for the interest in MLS.

So in this country we moved into an MLS program which had its genesis, figures 4-13, and 4-14, on the federal side on the Air Traffic Control Advisory Committee deliberations and report in 1969 and almost simultaneously in RTCA Special Committee 117, where they tried to look at the number of alternative solutions that were then appearing and began the process of narrowing down to a common, compatible signal format. The response to SC-117 on the government side was to write, and agree on a national program in 1971. We find ourselves now in about the fifth year in that program and although we had our ups and downs, we conform pretty much to the outlines of that program, and certainly follow it very closely in spirit.

Back at the end of 1974, there evolved from the U.S. program something called the Time Reference Scanning Beam technique (TRSB), which was, at that time, judged to be superior to the other alternative we were looking for, the Doppler scan. That technical decision was ratified in January 1975 and it provided us with the opportunity for the United States to give to ICAO a candidate system which would then be considered for international standardization.

As you can see, we provided that submission in December 1975. Other countries also provided submissions at that time that activated the international competition. That activity reached a milestone in March 1977 when the ICAO panel of experts decided, as we had previously, that Time Reference Scanning Beam was the technique which they would recommend for international standardization.

In the very recent past, the RTCA has presented a report giving its views relative to MLS implementation, and I prefer to think of that as a report provided to the FAA, so the FAA has the views of the RTCA. By this method, the industry and the user community views can be reflected in our plans.

The last milestone I've indicated here is the forthcoming ICAO worldwide meeting, now scheduled for April 1978, when 140 states of the ICAO will come together for the process of specifically making a selection of the international standard system.

Now speaking of the United States' program, I've chosen here to show the attributes of those two systems which probably represent something of more interest to this audience than the other configurations, figure 4-15. The SCMLS, The Small Community MLS, is something that some people call a Microwave ILS in that it provides the benefits of microwave propagation, the benefits of the MLS tracking receiver and so forth, but provides a narrow band of precise guidance (plus and minus 10 degrees around centerline), and left/right guidance out to a larger sector.

The other system which falls into the Cat I/Cat 2 category, is called the Basic System. That is the system which would provide that same kind of precise guidance over a wider sector for more difficult environments and for longer runways.

Today we will talk principally about small community systems. I have shown here some costs, figure 4-16, and we have to depend upon the economists and analysts to give us these costs because we have not produced production quantities of this equipment. On the avionics side, considerable work has been done by Bendix but NARCO and AEL are under contract to NASA to develop a low-cost Time Reference Scanning Beam Receiver. They are targeting in on a price of $1300 which I hope you find to be very attractive. They don't anticipate at this juncture that they will have any difficulty in meeting that target.

On the ground side, the prices get a little bit higher, but you will see included in those prices some things one does not normally associate with the landing system itself, such as markers and certain testing, flight inspection and that sort of thing. The thing I'd like to point out is that the electronics, the ground system hardware, costs on the order of $65K to $70K which we believe is a very economical price tag and is very competitive with other systems of less capability being offered on the market today.

Through this development program, we have undertaken to build not only the feasibility models of hardware, but prototype hardware. I have indicated here that Texas Instruments, Bendix and a small organization in Massachusetts, Meyer Associates, have delivered hardware to us, figure 4-17. On the field here at NAFEC are three small community systems and I will be showing you some pictures of those in a moment. In the future are the more sophisticated systems including some systems for the military and a very challenging system which would be developed for shipboard use by the Navy for carrier landing.

In terms of hardware, figure 4-18 shows the Bendix Small Community azimuth and companion elevation stations as we go through. The little block behind the picture in the foreground is one of the earlier MLS systems not associated with the current program. This azimuth station and its corresponding elevation station are installed at Runway 8 here at NAFEC. Figure 4-19 depicts the Bendix Small Community elevation station. Unfortunately, I don't have a good comparison of this with a glide slope, but you would see this whole structure is something on the order of 10 feet high, with some snow clearance on the bottom. Figure 4-20 is a rear view of that same antenna and it's intended to show the built-in electronics so there is no shelter. The equipment is self-contained and maintained at the field site.

Figure 4-21 exhibits Texas Instruments version of the same equipment, slightly different form factor, but it is built to the same performance specifications. Figure 4-22 is the elevation station that goes with it. Now here you see a different manifestation that provides the same signal in space and would be used with the same receiving equipment. Figure 4-23 shows the Meyer Associates system. On your left is the azimuth station, and on your right is the elevation station. There are three different manufacturers' approach to providing the same signal quality in space. We think that this diversity shows the strength and flexibility of the system that we are offering.

Shown in figure 4-24 are the Bendix avionics that developed in Phase III. A very simple antenna and we have shown the conventional CDI to indicate that it requires no special instrumentation in the cockpit for the user. Figure 4-25 depicts a mock-up of the NARCO-AEL work, which is breadboarded or brassboarded now, and which will be flying very shortly. This is the one we associate with the $1300 pricetag.

Now figure 4-26 gets a little sporty. I'm trying to give you a representation here of the kind of data that we are getting from the small community systems. This is an accumulation of statistics associated with the Bendix Small Community system. The bound shown across the extreme right hand side there, .33° (plus or minus) represents Cat I bounds, or something like a plus or minus 44 feet at MDH for Cat I. You can see the results are very well within that limit. If I can direct your attention to the center of the graph, which is centered on the runway centerline, the specification for autoland there is .15° so even in the Small Community system, we were providing autoland quality guidance at centerline.

Figure 4-27 is another one of the amalgamated statistics. Here again, shown across the top and bottom are the Cat I requirements which translate to 10 feet at MDH. Here on a 5-mile orbit, it's around plus or minus 80 feet. Again, if you look at the centerline region, we are within the limits that one would associate with autoland. We are getting elevation coverage with this kind of quality signal down to about 30 feet above the ground, and azimuth down to about 10 feet above the ground. That is about where the laws of physics permit you to go, so we think we are getting very good quality out of this system and we believe it typical of such TRSB equipment.

I've tried to indicate in figure 4-28 what I think have been the general aviation concerns, which should apply to Small Community MLS. We think you want simple safe inexpensive systems, easy to install, which have standardization, and that will have the wide deployment which would give you the promise of the economies of scale. We think that the systems that I have just showed you with the kind of performance that we are getting from these, and the promise of our evolving development, are such that we are delivering on those promises.

Finally, what I would like to say is that the general aviation community has had a considerable influence on the things that we have undertaken and on the priorities that we have followed in the program. In the top block of figure 4-29 I have shown those arenas in which the general aviation voice has been raised in which we have listened to your concerns. In the middle I would like

to stress that the United States program has placed a concentration in the prototype program, on Small Community systems, and that's why we do have three prototype systems that have been delivered and are here at the field. Certainly we have higher performance systems which we have used as test beds and so forth, but we have elected to place a priority in the prototype program on those which we hope come closest to your requirements.

In closing, I would like to say that there are some opportunities which will be presented in the very near future in which we will be asking for your comments in one form or another. I hope that you will continue to offer them and I hope that we will continue to be responsive in listening to them.

FIGURE 4-11

WHY MLS?

- SINGLE, COMMON LANDING SYSTEM SATISFYING ALL OPERATIONAL REQUIREMENTS (OR's) OVER LONG TERM
- ILS DOES NOT SATISFY ALL OR's
- ILS NEARING END OF USEFUL LIFE. TECHNICAL/OPERATIONAL LIMITATIONS INCREASINGLY DIFFICULT TO SOLVE
  - CHANNEL LIMITATIONS (250 SYSTEM SHORTFALL)
  - SITE/TERRAIN SENSITIVITY (VHF/UHF)
  - ADVERSE WEATHER EFFECTS
  - SIGNAL QUALITY LACKING (ROUGHNESS, MULTIPATH)
  - ANALOG SYSTEM
  - OPERATIONAL INFLEXIBILITY
  - HIGH COST CONSTRAINS DEPLOYMENT

FIGURE 4-12

ATCAC REPORT (12/69) RECOMMENDED MLS AS P/O UG3RD

RTCA, SC-117 (12/70) AFTER 3 YEAR EFFORT FURNISHED COMPREHENSIVE OPERATIONAL/TECHNICAL REQUIREMENTS FOR A NEW MLS MEETING CIVIL/MILITARY NEEDS WITH COMMON, COMPATIBLE SIGNAL FORMAT

NATIONAL PLAN FOR DEVELOPMENT OF MLS (7/71) ESTABLISHED A 5-YEAR PLAN, ENDORSED BY FAA, DOT, DOD, NASA

FAA NOW IN 5TH YEAR OF DEVELOPMENT PROGRAM GUIDED THROUGHOUT BY USERS/ INDUSTRY VIA MLS ADVISORY COMMITTEE

TIME REFERENCE SCANNING BEAM (TRSB) MLS SELECTED BY 100 EXPERTS IN 4 MONTH EFFORT (12/74)

FIGURE 4-13

MLS PROGRAM MILESTONES (CONT'D)

- TRSB SELECTION RATIFIED BY MLS EXECUTIVE COMMITTEE C/O FAA, DOT, DOD, NASA — JAN 75
- U.S. SUBMISSION TO ICAO FOR TRSB MLS AS INTERNATIONAL STANDARD — DEC 75
- AWOP-VI SELECTION OF TRSB MLS — MAR 77
- RTCA (SC-125) COMPLETED USER RECOMMENDATIONS FOR MLS IMPLEMENTATION STRATEGY — JULY 77
- ICAO ALL WORLD MEETING — APR 78

FIGURE 4-14

PRINCIPAL FEATURES	SCMLS	BASIC
• PERFORMANCE CAPABILITY	CAT I	CAT I/II
• CURVED APPROACH	NO	YES
• SELECTABLE GLIDE PATH	YES	YES
• COVERAGE (AZ)	± 10° PROPORTIONAL ± 40° LEFT/RIGHT	± 40° PROPORTIONAL
(EL)	≤ 15°	≤ 20°
• RANGE	20 MILES	20 MILES

FIGURE 4-15

AVIONICS	$1300	• FIXED GLIDE ANGLE • LESS CDI/MKR BEACON • 250 FT - 3/4 MI (W/O LIGHTS)
GROUND	$124,000 (AUSTERE)	• INCLUDES AZ, EL, MKR BCNS, INSTALLATION, FLT. INSPECTION, SPARES, ETC.
	$214,000 (FAA SPECS)	• INCLUDES ABOVE PLUS: SPARE PARTS, TEST EQPT., REGIONAL ENGINEERING, RELIABILITY TESTING
	$65 - 70,000	• HARDWARE COST ONLY

FIGURE 4-16

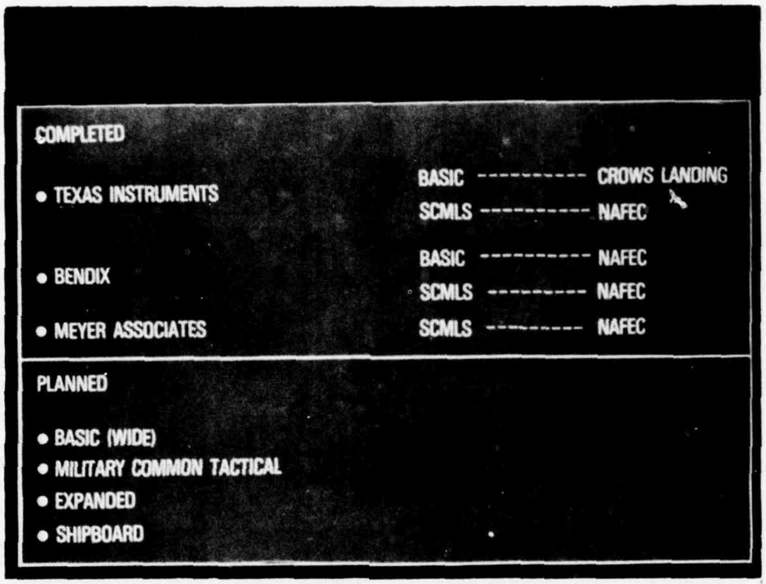


FIGURE 4-17

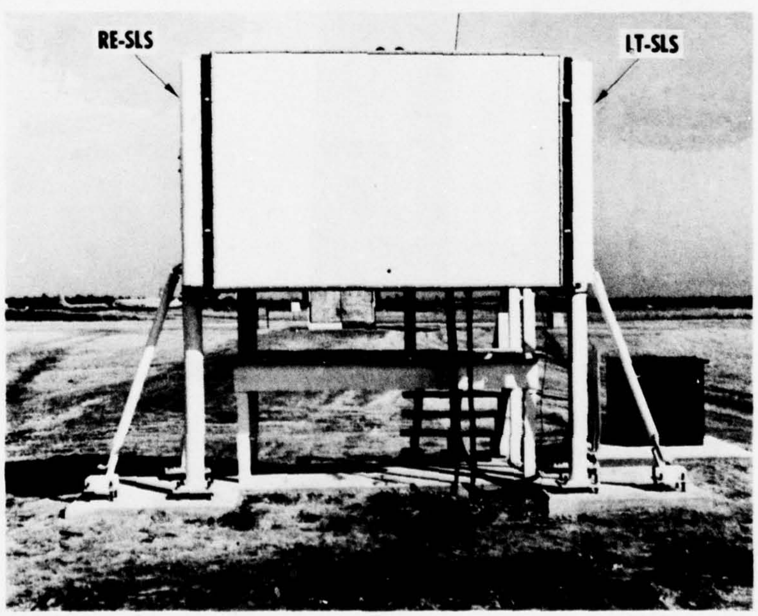


FIGURE 4-18

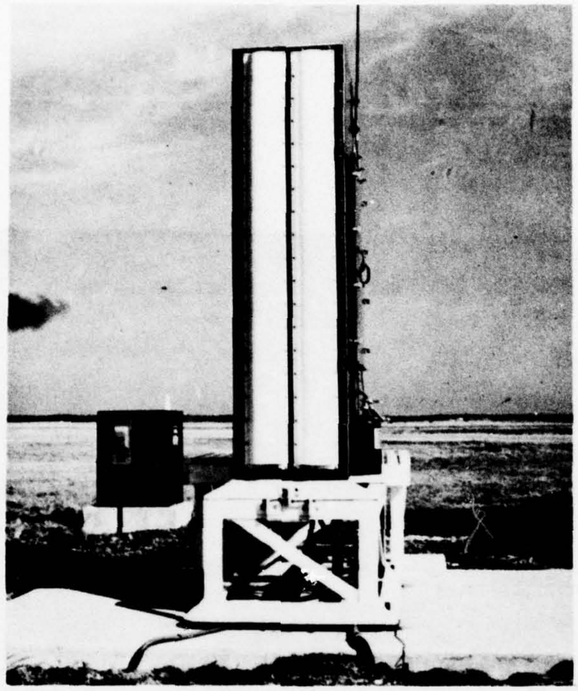


FIGURE 4-19

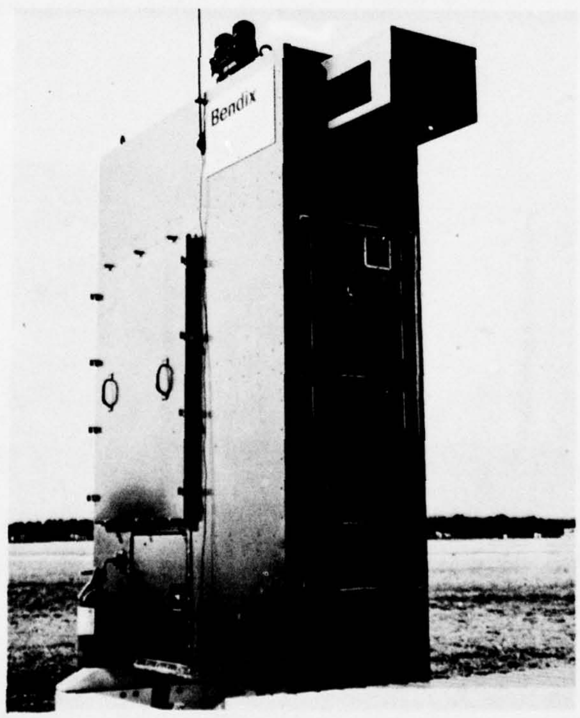


FIGURE 4-20

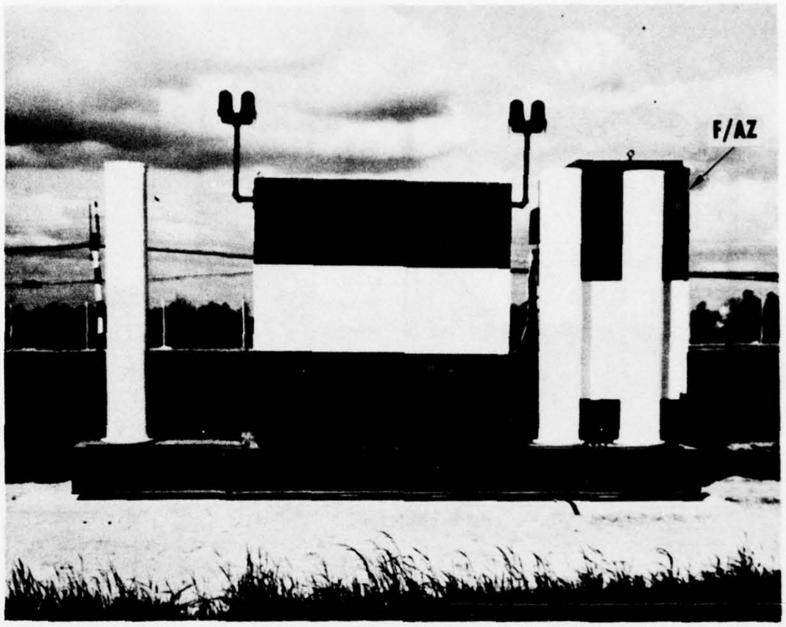


FIGURE 4-21

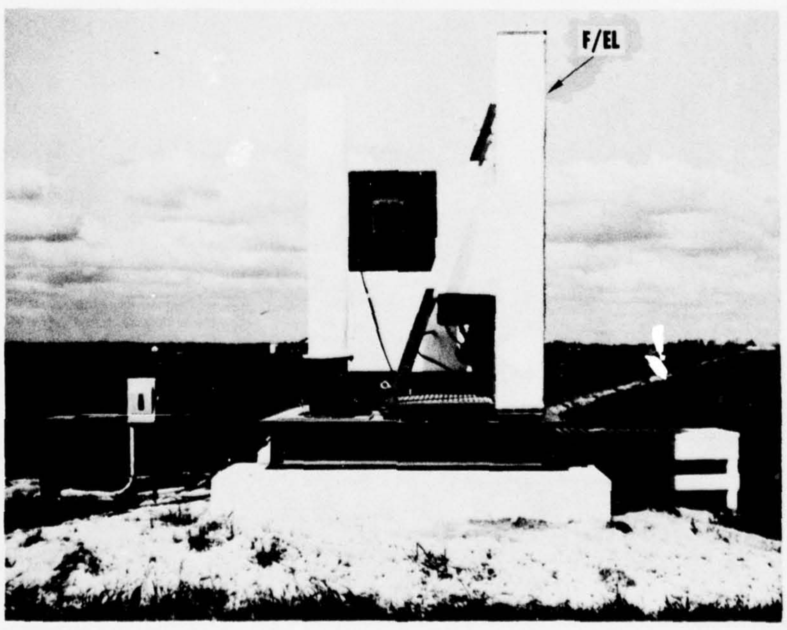


FIGURE 4-22

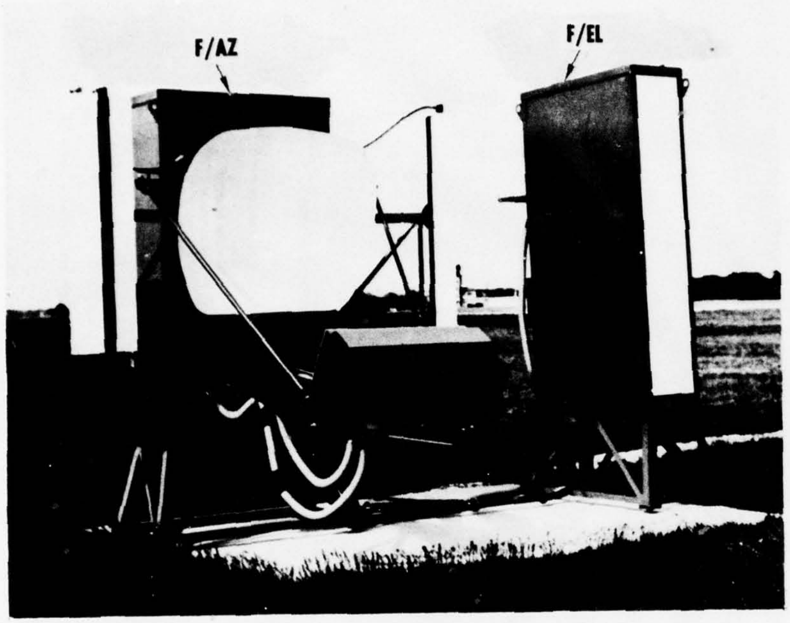


FIGURE 4-23

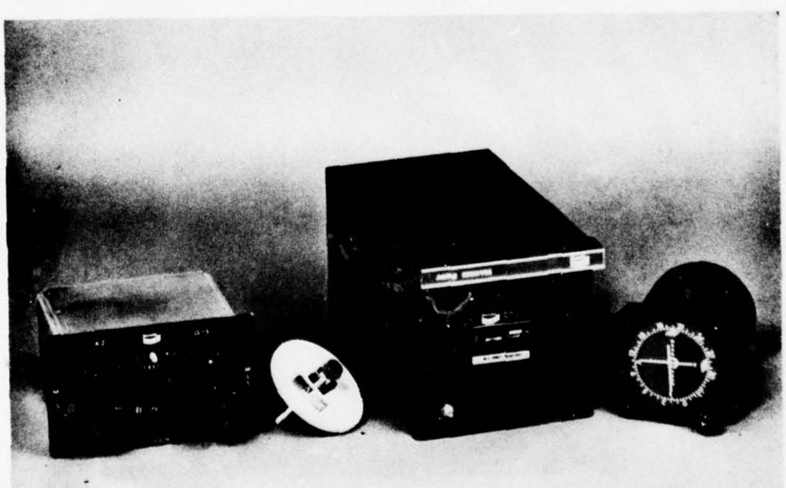


FIGURE 4-24

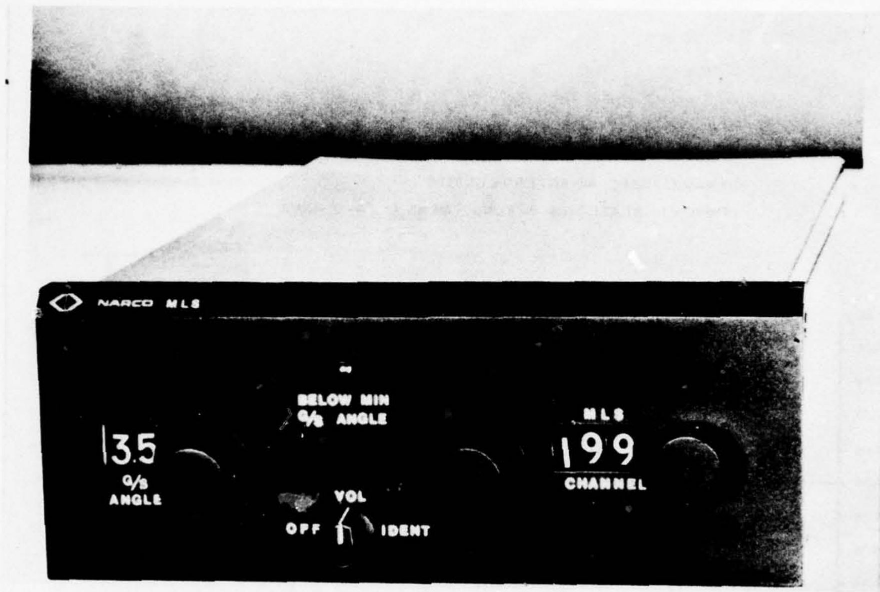


FIGURE 4-25

U. S. PHASE 3 TEST ---BENDIX SC

DYNAMIC TEST: EL ANTENNA ORBITS

COMPOSITE STATISTICS 20 RUNS MEAN +/− 2 SIGMA

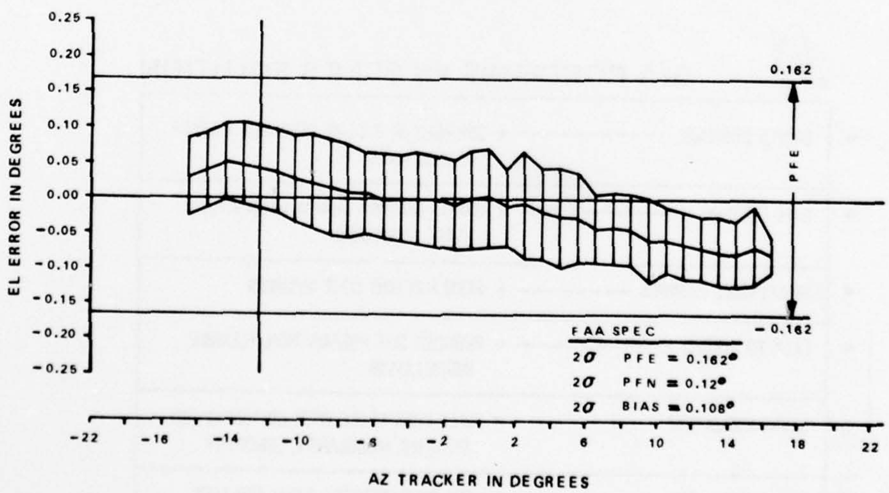


FIGURE 4-26

U. S. PHASE 3 TEST---BENDIX SC

DYNAMIC TEST: AZ ANTENNA ORBITS

COMPOSITE STATISTICS 20 RUNS MEAN +/− 2 SIGMA

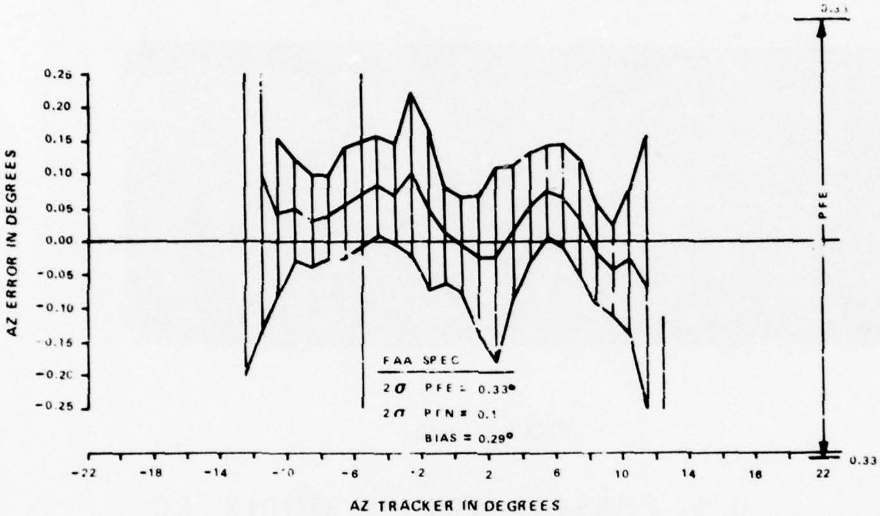


FIGURE 4-27

G/A CONCERNS VS SCMLS SOLUTION

• SIMPLE SYSTEMS	• STRAIGHT-IN, ILS-LIKE GUIDANCE MARKER BEACON FIXES
• SAFE SYSTEMS	• HIGHLY RELIABLE DIGITAL DESIGN/SOLID STATE HARDWARE
• INEXPENSIVE AVIONICS	• $1300 FOR LOW COST AVIONICS
• EASY TO INSTALL	• REDUCED SITE PREPARATION, FLEXIBLE INSTALLATION
• STANDARDIZATION	• FULLY COMPATIBLE WITH SOPHISTICATED SYSTEMS, MODULARITY, LONGEVITY
• WIDE DEPLOYMENT	• LOW COST PROVIDES BASIC FOR LESS STRINGENT ELIGIBILITY REQUIREMENTS (APS-1 AND FAR PART 171)

FIGURE 4-28

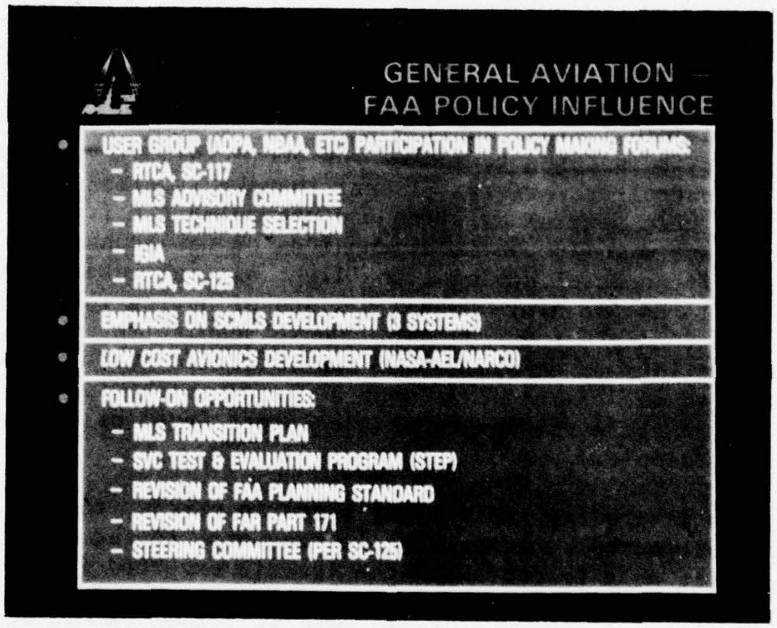

GENERAL AVIATION —
FAA POLICY INFLUENCE
USER GROUP (AOPA, NBAA, ETC) PARTICIPATION IN POLICY MAKING FORUMS:
– RTCA, SC-117
– MLS ADVISORY COMMITTEE
– MLS TECHNIQUE SELECTION
– IGIA
– RTCA, SC-125
EMPHASIS ON SCMLS DEVELOPMENT (3 SYSTEMS)
LOW COST AVIONICS DEVELOPMENT (NASA-AEL/NARCO)
FOLLOW-ON OPPORTUNITIES:
– MLS TRANSITION PLAN
– SVC TEST & EVALUATION PROGRAM (STEP)
– REVISION OF FAA PLANNING STANDARD
– REVISION OF FAR PART 171
– STEERING COMMITTEE (PER SC-125)

FIGURE 4-29

MEETING GENERAL AVIATION NEEDS FOR THE FUTURE IN THE EVOLVING AIR TRAFFIC CONTROL SYSTEMS

MR. DAVID SHEFTEL

The next speaker is Sieg Poritzky. He is the Director of the FAA Office of Systems Engineering Management.

MR. S. B. PORITZKY

We haven't talked much in this session about air traffic control and where it is going and what it is doing to you or for you. This session is to touch on air traffic control and safety. I want to make it clear at the outset that our motive is to help general aviation and not to stifle it in a super complex, super-automated system. In public discussions of new technology and sophisticated air traffic control devices, the light aircraft user often wonders what such miracles will do for him. He has visions of having to carry avionics equipment of great complexity and cost, and to acquire the skills of an engineer and a couple of pilots to manage in the sophisticated system. This is not where FAA wants to go. Instead, we want a system which will produce safety and efficiency for all participants at the lowest level of cost and complexity. The challenge is simple.

General Aviation is growing rapidly and there is steady, though moderate, growth in air carrier operations. The improvements to the ATC system now under development, while able to cope with the traffic expected in the next few years and potentially very productive in reduction of delays and improvement of system safety and efficiency, will run out of steam as growth in the number of users and number of operations continues. We must thus look beyond the present state of improvements to new initiatives which will produce safety, capacity, and productivity in the system, without denying services to those who need them, and without compromising safety.

I would like to talk to you a little about some of the problems and opportunities to meet general aviation's needs in the evolving ATC system. Let me start with the forces, figure 4-30, which drive the FAA E&D program.

They are:

The growth of general aviation operations.

The changing nature of General Aviation.

Safety trends and the need to maintain and improve the safety level.

Capacity considerations both in the airspace and at major terminals, and the need to contain costs of FAA services.

General Aviation forecasts, figure 4-31, all point to continued rapid growth, barring major economic or fuel availability problems. By the year 2000, general aviation operations are expected to be four times 1975 values, and IFR aircraft handled approximately six times the 1975 levels. Most interesting about these year 2000 projections is the increasing proportion of total operations and aircraft handled which are General Aviation. About two-thirds of the instrument operations, figure 4-32, and half the enroute traffic is expected to be General Aviation in that time frame.

Certain elements of General Aviation are expected to operate more larger aircraft, figure 4-33, and to become more sophisticated in performance and capability. The number of IFR-rated pilots is expected to more than triple by the year 2000, and multiengine aircraft and turbine aircraft will command a larger percentage of the G.A. fleet.

Maintaining and improving the safety level is obviously a driving factor. While aviation safety has improved dramatically over the years, the accident levels that persist in some categories of General Aviation, figure 4-34, combined with the large growth expected, remain a matter of concern.

This table provides accident statistics for the domestic air carriers, G.A., and automobiles. The G.A. and the motor vehicle statistics include all occupants whereas the airline statistics include only the passengers. However, the airline rates would not be significantly different than shown if the crew and crew miles were included. Another way of looking at the statistical comparisons is the fatality rates per hour of flight. For the years 1974 to 1976, there were 3.9 G.A. fatalities per 100,000 hours of flight in comparison to 3.6 for the air carriers in domestic and international service.

The National Transportation Safety Board accident reports for 1974 and 1975 list the top 10 most frequently cited causes, figure 4-35, of fatal general aviation accidents. The top nine, which appear in both years' reports, are shown on the figure. The majority of the leading causes were weather or some type of pilot error.

Although fatal midair collisions are not listed among the top factors in general aviation accidents, about 4 percent of the general aviation fatalities in CY-1976 resulted from collisions. We also know, and are concerned, that as traffic grows, collision risk---at least in theory---will rise faster than the growth itself and, as you know, the prevention of collisions is the most important direct task FAA has in air traffic control.

While a collision involving commercial air carriers, is of course, the most dramatic event and generally results in major loss of lives, the less well-publicized collisions between general aviation aircraft, which comprise 66 percent of all midair collision fatalities (1964-1975), are also a matter of concern.

Another factor is airport capacity. Our studies indicate that there are no magic solutions that will provide the capacity increases needed to meet the forecast demands at the large airports serving both air carrier and general aviation. There appears to be no substitute for new airports and runways.

Delay trends at 25 major airports show that 22 will be severely congested by the year 2000. Why should general aviation care? Because these 25 airports may be serving about 3 million general aviation operations annually. As these airports become more congested, airport operators may increase landing fees to discourage marginal operators from using valuable airport capacity. Beyond that, the cost of delay to general aviation operators at these airports would, of course, rise substantially.

Besides safety and capacity, FAA is trying to slow down and, if possible, to reverse the increasing cost of FAA services. Air traffic control personnel staffing in the year 2000, even with implementation of the current developments, is expected to rise by 50 percent. This is far less than the increase that would be required if we did not implement the system improvements, but it is still higher than we want it to be. At the same time, if new approaches involve the carriage of new or different avionics systems in the aircraft, they could lead to a substantial rise in the price of entry into the system. We want to restrain that rise to the extent possible.

In developing solutions to the problems I have outlined, we must use the existing system as a starting point. Change must be evolutionary and we must avoid obsoleting existing systems, both air and ground, wherever possible. There is no sense in assuming that we could start a new system from scratch.

The present system development program, figure 4-36, as I have already noted, will produce significant benefits. The chart shows our assessment of the areas in which these programs can be expected to have impact. We expect the Discrete Address Beacon System (DABS) with its integral data link to offer major advantages to General Aviation and all other users of the airspace. Our aircraft separation assurance effort, which I will touch on in a moment, will permit General Aviation to participate at various levels of service in reducing the threat of midair collisions. Improvements in the air traffic service itself are expected to provide smoother and more efficient traffic flow into and out of major terminal areas.

For approach and landing, we will continue to make ILS glide slope and localizer antenna improvements, and are moving toward eventual transition to the Microwave Landing System. This system, figure 4-37, should be of particular interest to General Aviation since it promises a relatively low cost, low maintenance, and site-insensitive service which we think may have application to many airports which do not now have precision approach and landing service.

In the area of Flight Service Stations, as you have already heard, we are pursuing a program of modernization and automation. The main thing we want to do here is to answer the phones when they ring and provide service efficiently to those who want it.

You have already heard of the work we are doing on Wake Vortex Advisory and Avoidance Systems and on Wind Shear. We think these programs are especially important to the light general aviation aircraft---more perhaps for the knowledge gained which we can pass on, than for new devices.

As you know, a major category of general aviation accidents is in the area of pilot factors. We have strengthened our FAA effort in a program we call Aircrew Performance Enhancement and Error Reduction (APEER) and I will touch on that in a moment.

You are all aware of the enroute Conflict Alert program and our efforts to extend this program to the terminal area. Conversely, a Minimum Safe Altitude Warning System is now in use at many terminals, and we hope to extend it to the enroute airspace as well, to provide warning to aircraft which stray below minimum safe altitude.

Before going into some of the more advanced work, let me talk for a moment about the Aircraft Separation Assurance program, figure 4-38. This is a complicated subject on which we have had many, many discussions, both formal and informal, with the whole aviation community. Our program has the support of the bulk of the aviation community, both General Aviation and air carrier.

We expect that the primary responsibility for assuring separation of controlled aircraft and for the prevention of collisions will remain in the ground-based ATC system. We are working to automate some of that separation function. The Conflict Alert System is a step in that direction. We expect Conflict Alert to functionally evolve into an Automatic Traffic Advisory and Resolution Service in which certain information will be given automatically to the pilot about traffic of concern to him, and eventually to provide conflict resolution instructions automatically by data link under certain circumstances. Our studies have shown that data link is provided in the least costly way by utilizing the ATC transponder, but it will require those who wish to avail themselves of the service, to make a transponder change. We think it will be appropriate, perhaps in 1980, to assure that new transponders purchased will have the DABS capability in addition to ATCRBS. The transponder is the key to much of the future system.

With respect to airborne collision avoidance systems, many of you are aware that the industry and FAA have been working since 1956 on such systems. Our studies and many discussions with the users have led us to conclude that no one system can independently solve the entire midair collision problem. We have concluded, as has the bulk of the aviation community, that a Beacon-based Collision Avoidance System (BCAS) is the only approach which can provide maximum protection against collisions, both in and outside of controlled airspace and radar surveillance. The collision avoidance system we are developing is not cheap, nor is it simple. Yet, it appears to be the only approach which solves enough of the problem to make carriage of such a system worthwhile. We obviously do not expect all of General Aviation to equip with such BCAS, but a user equipped even with a basic altitude-reporting ATC transponder can get protection from aircraft carrying the full BCAS.

Several levels of implementation will be possible. The aircraft carrying a DABS transponder with its data link will achieve a higher level of protection and, of course, general aviation aircraft equipped with the full BCAS will achieve the full protection. We are planning in our BCAS development program to work diligently to provide a moderate cost system which would be available to those general aviation users willing to take advantage of it. We expect to have a draft BCAS standard for user and industry consideration by the end of next year, and a final standard, after exhaustive operational tests, by the end of 1981.

Let me move now to some efforts which go beyond the present development program, figure 4-39. There is no fine line between the present program and advanced systems. The fruits of the work now going on will, of course, be with us for a long time.

I want to dwell on a few efforts which look beyond the present programs.

One promising and exciting effort is an investigation of ways and means to automate the ATC process in the enroute area. Almost all other automation efforts have been concerned with automating information storage, retrieval, processing and display to assist the controller. In this project, we are experimenting with ways to accomplish the control function using a computer with a data link or a voice message generator to accomplish all the routine functions of enroute ATC. There is the possibility of reducing some constraints on flights imposed by the present ATC system, and of reducing, or at least containing the cost of operating the system with increasing demand for services. Experiments in automated ATC are being carried out in a simulated environment utilizing the Front Royal (Virginia) ARTCC Sector as a model.

An approach to automation from the bottom up, figure 4-40, is the Automated Terminal Service (ATS). FAA currently operates 445 towers, and there are projections that indicate that an additional 87 airports will become tower candidates within 25 years. Considerable savings in operation and maintenance costs can be achieved by delaying or eliminating the need for new towers by a service we have called an Automated Terminal System. That system would transmit traffic advisories, IFR clearances, and airport related information to pilots over the VHF radio, and could serve as an unmanned, low-cost alternative to a tower installation, but one which would have an impact on the relatively large number of midair collisions which occur at uncontrolled airports. This system is currently under feasibility development and is now going into test.

In the long run, the ATS may be applicable to a tower environment by using selected clearances, monitoring separation, sequencing, and providing other routine functions to relieve the live controllers. We will be working with the general aviation community to establish feasibility and pilot acceptance of this concept.

I mentioned the aircraft separation assurance program. We have an effort, figure 4-41, that goes beyond this work. We want to examine, in a systematic way, alternative approaches to the present system of aircraft separation and air traffic control. There has been much discussion over the years about

evolution from the current air route system to a more random operation in which separation is provided in a tactical way without long-term preplanning of airspace utilization.

On the other hand, there have been proposals for what is frequently called strategic control, in which the entire ATC process is rigidly preplanned and airspace reservations would be used as a means of exercising separation and control. The potential of providing information on other traffic in the cockpit opens the possibility of giving the pilot certain responsibilities for maintaining his own separation.

Widespread use of airborne collision avoidance systems could permit another way of aircraft separating themselves from each other with less direct control by the system. Each idea has adherents and each method has advantages and disadvantages. The work we are initiating will take a hard look at the alternatives to help us objectively establish the feasibility, benefits, and problems of each. This is a difficult area, one in which strong opinions abound. As we proceed into the work on alternative separation concepts, we will be looking for help and guidance from the general aviation community as well as from the other users.

Computers are basic tools in a modern ATC system, and they are working hard at 20 Air Route Traffic Control Centers and in over 60 high-density terminals. Much of the work in our current development program dealing with automation of the ATC system requires the expanded use of computers for processing, display, and transmission of data. Yet, computer technology has changed dramatically, and we must look toward the day when the existing generation of data processing systems will no longer satisfy the need. A part of our advanced system development effort is to pave the way for introduction of a new level of computer capability.

Finally, I would like to talk about our human factors, figure 4-42, or Aircrew Performance Enhancement and Error Reduction (APEER) Program. Many accidents and fatalities have been linked to the human error problem. Pilots not maintaining proficiency represent a particularly high incidence of errors, but even with experience, the human error problem remains. It has been estimated that 87 percent of general aviation fatal accidents involve pilot error.

It is essential that we learn more about human limitations so that we may take best advantage of human capabilities. Automation, both in the aircraft and in the ATC system, adds a new dimension to the problem. We are developing an extensive program in this area, and we hope to work closely with you and other users on the problem, as well as with NASA and the military. Among the tasks we have identified which directly affect General Aviation are the following:

> To investigate visual illusions and visual cues and their relationship to safe operations.

To study low-cost training methods and new training devices, and to assess the effectiveness of training on accident prevention.

To evaluate cockpit and ATC operational procedures as these may impact on flight safety.

To assess cockpit displays and controls, and how these can be simplified and improved for more error-free operation.

A project with near-term application is a computerized data base management system of general aviation accident data: the Flight Standards Safety Information and Analysis System (SIAS). We will be working with general aviation user organizations, as well as with others, to be sure that our program in this area is responsive to their needs.

In conclusion, figure 4-43, let me repeat FAA's major program thrusts.

Improving safety has been, and will remain, FAA's primary mission.

Second, we must find ways to increase capacity beyond what we can expect from the current major development program. We will seek to find solutions which will give General Aviation as much freedom in airspace utilization as possible. We must find and implement improvements that have high payoffs if we are to avoid the undesirable alternatives of growth constraint by regulation and airport and airspace congestion.

Third, we must increase ATC system productivity and contain FAA costs for operation and maintenance of a growing system.

We want to merit the support of the general aviation community and we will solicit your guidance in these endeavors.

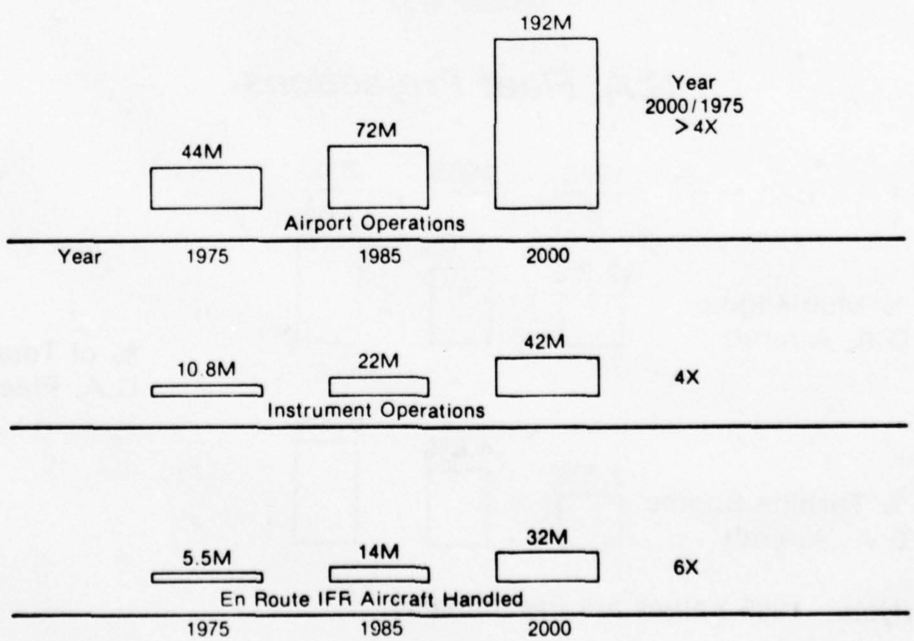
Driving Forces for E & D

- Traffic Growth - Increasing Levels of G.A. Activity: IFR, VFR, En Route
- Changing Nature of G.A.
  - More Sophistication
  - Larger Aircraft
- Safety Levels and Accident Causal Factors
- Inadequate Capacity and Forecast Increases in Congestion
- Increasing Cost of Service

FIGURE 4-30

Forecasts of General Aviation Activity

(1985 Values are Preliminary)



VG 2a

FIGURE 4-31

Forecasts of General Aviation Activity as a % of Total

(1985 Values Preliminary)

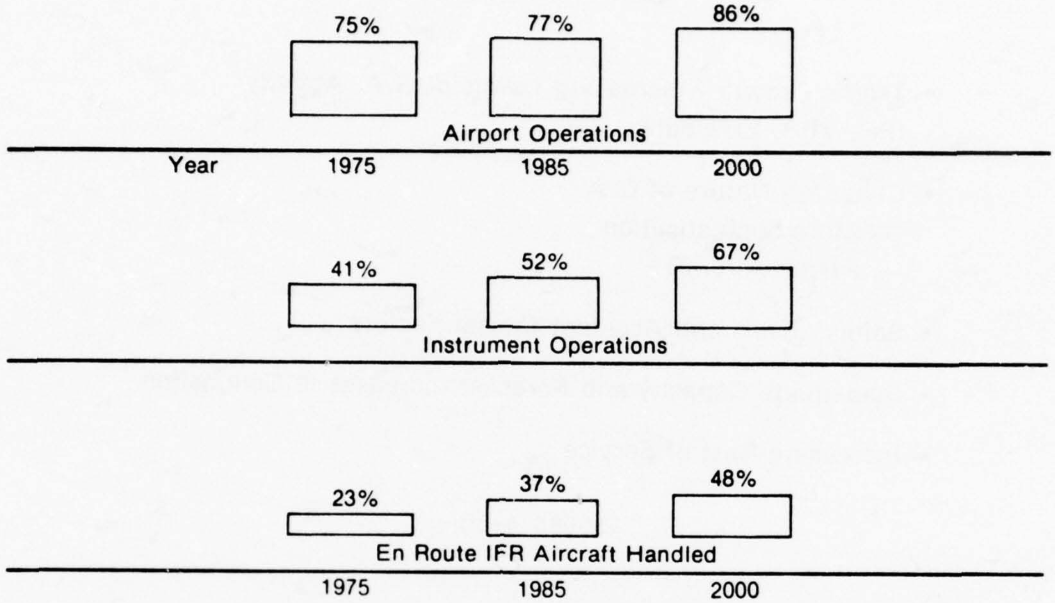
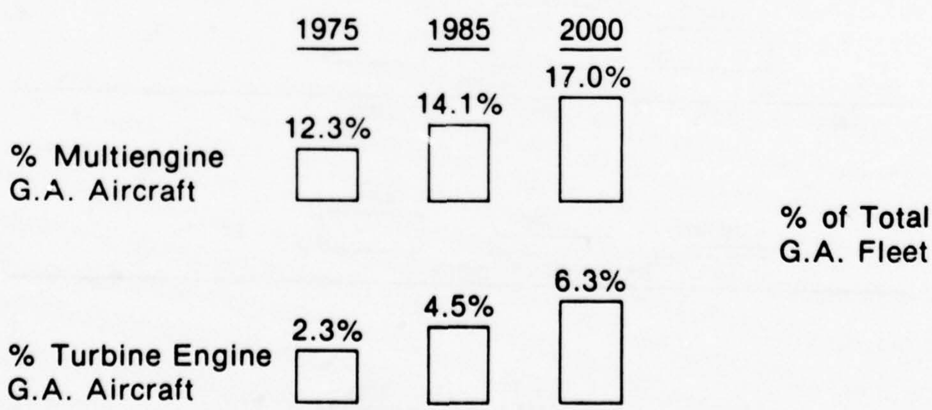


FIGURE 4-32

G.A. Fleet Projections



(Note: 1985 Values are Preliminary)

FIGURE 4-33

Fatality Rates per 100 Million Passenger Miles 1/

Year	Domestic Scheduled Airlines	U.S. General Aviation 1/	Passenger Automobiles and Taxis
1949-51	1.26	47	2.9
1959-61	0.67	24	2.2
1972-75	0.11	19	1.6

1/ G.A. rates are fatal accidents per 100 million plane miles; it approximately equals fatalities per 100 million passenger miles.
RATES FOR G.A. AND PASSENGER AUTOMOBILES AND TAXIS INCLUDE ALL OCCUPANTS AS PASSENGERS.

FIGURE 4-34

Most Frequently Cited Causes/Factors in Fatal G.A. Accidents 1/ *(1974 & 1975)*

Terrain	— high obstructions
Weather	— low ceilings — fog — rain
Pilot	— failed to obtain/maintain flying speed — continued VFR flight into adverse weather conditions — spatial disorientation — inadequate preflight planning — improper in-flight decision or planning

1/ NTSB includes in G.A. all U.S. civil aircraft other than those engaged in U.S. air carrier operations.

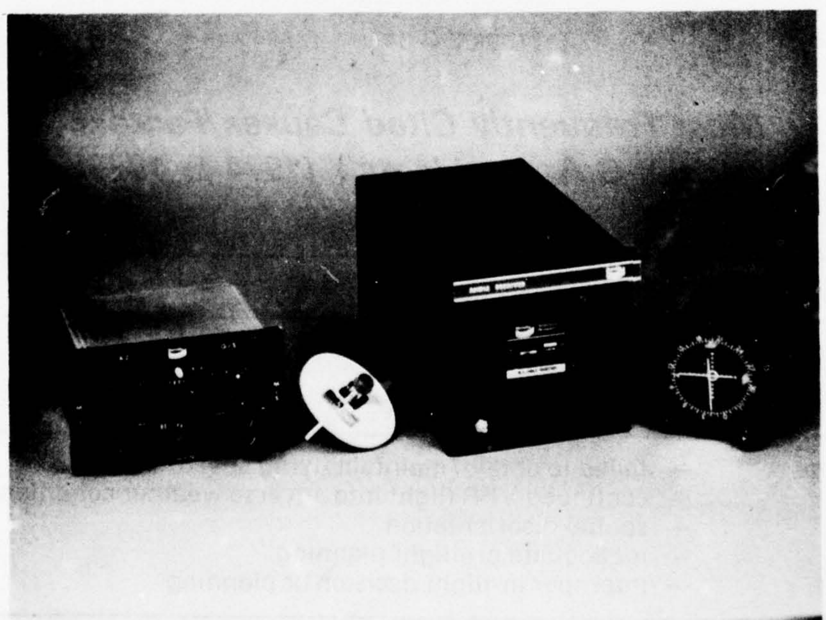
FIGURE 4-35

Selected E&D Objectives vs. Current Major Developments

OBJECTIVES

Functions	Safety	Capacity	Productivity	User Costs	Developments
Surveillance & Separation	O		O		Discrete Address Beacon
	O				Aircraft Separation Assure.
ATC Operations & Automation	O	O	O	O	Air Traffic Service
			O		Data Handling & Display
	O				Terrain Avoidance
Navigation	O	O	O	O	Area Navigation
	O	O		O	ILS & MLS
	O				Visual Guidance
Flight Services	O		O		Automation of FSS & Improved Weather Services
Operations	O	O		O	Wake Vortex Avoidance
	O				Wind Shear Detection
Aircraft & Airman Safety	O				Aircraft Crashworthiness & Design
	O				Human Factors & Pilot Training

FIGURE 4-36



G.A. AIRBORNE MLS HARDWARE

FIGURE 4-37

Aircraft Separation Assurance

- Ground Based Separation

Conflict Alert ⟹ Automatic Traffic Advisory & Resolution Service

- Airborne Collision Avoidance

Low-Cost BCAS → (More Protection) → Full-BCAS

Carriage of Altitude-Reporting Transponders Is a Necessary Prerequisite to This Service

FIGURE 4-38

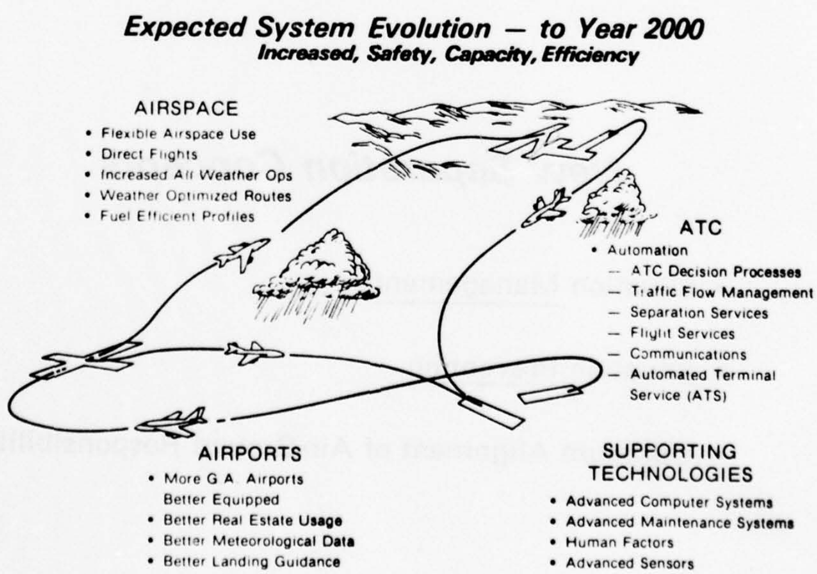


FIGURE 4-39

Automated Terminal Service

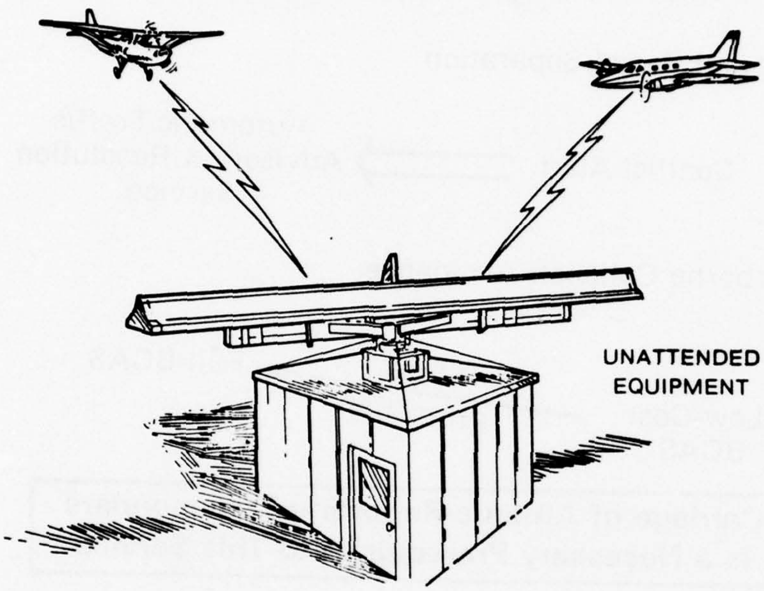


FIGURE 4-40

New Separation Concepts

- Situation Management
- Situation Prevention
- Optimum Alignment of Air-Ground Responsibility

FIGURE 4-41

Human Error R, E & D

- Visual Illusions & Visual Cues
- Low-Cost Training & New Training Devices
- Cockpit & ATC Operational Procedures
- Cockpit Displays & Controls

FIGURE 4-42

Major Program Thrusts

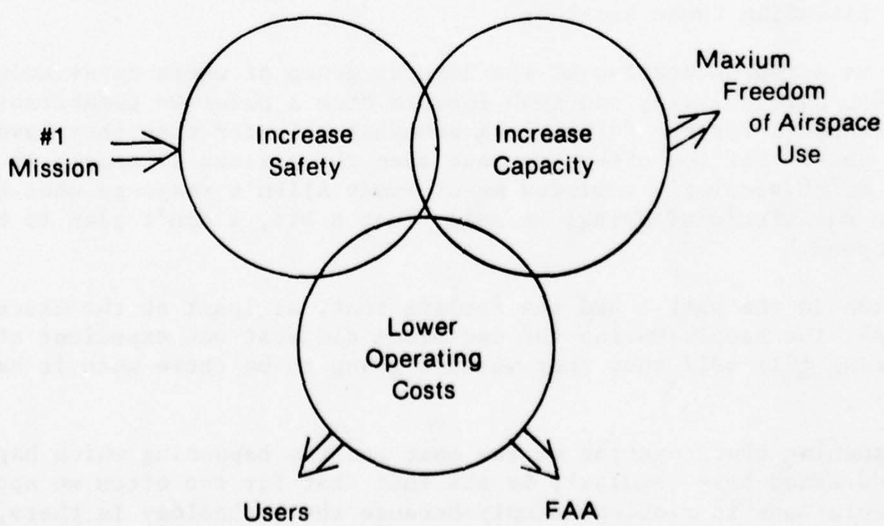


FIGURE 4-43

GENERAL AVIATION USER VIEWS TO THE EVOLVING ATC SYSTEM

MR. DAVID SHEFTEL

I want to introduce John Baker who is the President of Aircraft Owners and Pilots Association. Most of us know John from the time that he was the Assistant Administrator for General Aviation at FAA, and we are very pleased to work with him in his current role...John Baker.

MR. JOHN L. BAKER

I am pleased to be here, and I have a happy announcement to make; that is, I am not going to read my prepared statement. We have copies of it over here, and I would be appreciative if you take it because someone is going to have to be carrying all of those out of the dome. With the time constraints we have, plus the fact the soothing blue colors that Sieg had tend to be enervating, I notice myself dozing off and all of my colleagues nodding on occasion. I will try to keep it short.

I came with a technical presentation, but I am not going to bore you with it. I guess the observation that I have to make that is most relevant, and I think probably it reflects many of your own, is that I am pleasantly surprised that this opportunity even exists becuse it indicates there is some commitment beyond the lip service we had in the past of having talk sessions and communicating and so forth. I had resolved in my own mind sometime back that if we were going to continue to have the noncommunicating, communications session that we had in the past, I simply wasn't going to participate, because I oftentimes found that I learned more standing listening to myself and looking in the mirror than I did attending those sessions.

I believe, as a representative of the largest group of users in aviation, that if all of us, collectively, can push forward from a point we established here, that the prospects for the future look somewhat brighter than they have in the recent past. Far too often, we have seen the actions of people in the government which regularly reminded me of Woody Allen's response when he was asked if he was afraid of dying; he said, "not a bit, I don't plan to be there when it happens."

Far too often in the past I had the feeling that, at least at the executive level in FAA, the people making the decisions did what was expedient at the time being, knowing full well that they weren't going to be there when it happened downstream.

And the happening that concerns me the most and the happening which happily has been addressed here regularly is the fact that far too often we applied technical solutions to problems simply because the technology is there, and we haven't addressed the real problem which is this tremendous wave of increasingly sophisticated General Aviation which is coming downstream at us.

What I forsee, not withstanding Sieg's urging that we be evolutionary rather than revolutionary, is that if we don't do some bright, aggressive, innovative things in the near future, while we still have the luxury of some time, we're going to find that we have no options left downstream as we keep adding a thousand new airplanes a month to the system, most of which are far more sophisticated than they were 5 years ago; and we keep adding, hopefully, thousands of new pilots to this system, each of whom is more skilled than he was in the past. We are simply going to run against a blank wall of a total lack of capacity. And when the total lack of capacity confronts us, the only option available for the provider of the service is to constrain the use of the system. And those that are going to be constrained are those that are sitting here and those people who we represent.

I think it behooves us all to start banging on the drum as hard as we can, urging that the Congress set standards which are bright and innovative and aggressive for an indistry that should still be growing; we shouldn't be starting to atrophy at this point in our development. We haven't even figured out yet how to best use the airplane, and yet we have people tolling our existence in the future simply because we have not done the things necessary to accommodate to this wonderous machine we are all associated with.

So I say in the sense of evolution, I agree with Sieg; we can't scrap the system, we can't start over, nor does it do a lot of good to bemoan the mistakes we all made in the past regarding the system. But I do think that we have to be revolutionary and not accept the pedestrian approach we have seen demonstrated here. We have to look at things far more aggressively and across a broader spectrum of options if we are ever going to have a climate that we can grow in; and if we can't grow, then ultimately the FAA is going to have a tough time justifying its existence also. Because as I recall what the law said, they are mandated by the Congress to promote aviation.

Many of the options, which we have seen spelled out during the course of this session, are not promoting in any sense. They are saying--what is the lesser of a number of evils? How are they going to eliminate the part which is making the least contribution? I don't see that in their mandate from Congress, I think they've got to find a way to accommodate us, and it behooves each one of us to work with them in every way possible to ensure that they get that job done. I think we all have to pull together, the whole aviation community, because far too often we indulge ourselves in intramural warfare, and we are the last of the Mohicans: we are the smallest army around when you look at consumer groups and what has happened to us in the airport areas, and so forth. I think it behooves us to get together and all start pulling in the same direction on the oars so we don't continually turn around in circles, which we have done in the past.

In the competition for public resources on the national level, we are small potatoes; we, not just General Aviation, but the whole aviation community. I remember sometime back the dialogue that when deregulation came out we were going to have some thirty or forty thousand people out of business in the air carrier industry. There are towns in Michigan that have had more out of work regularly. So we can't think we are the big kid on the block. We have so

much to offer, but we are such lousy salesmen because we disembowel each other in public regularly. I think it behooves us to applaud what FAA is doing, to urge them to do more and do it more aggressively, and to remind them on a regular basis that ultimate determination as to whether they are doing the job well or not has to be made by the user, and that is you and us. The day they forget that, we get the club out and go back down and get their attention again, like you do with the donkey. And it is required on occasion, because wisdom in Washington is something we all think we are born with, and we obviously all know what is best for our fellow man. And that is not unique to government employees I might add; we have the same problems at AOPA and I am sure every other Washington organization does.

It is important that we stimulate a feedback from the people who are out flying everyday in our system, and we make darn sure that those users views are considered when we evaluate how effectively the job is being done.

To summarize, I would say the things we have to look for in this system are: one, simplification; it is far too complex, it has far too little capacity, and if we cannot simplify it, then no matter what system comes along, we are going to have chaos, ultimately, because the major user is the nonprofessional pilot; and if we make it so complete that the nonprofessional pilot cannot use it, the system has absolutely no value to anyone. And I think all of us, none of us at least are so beknighted as to think we have absolute right-of-way in the air. It is an area that we have a common requirement to insure that we are safe, and that we insure the safety of others using air space. And the third point that I will make is one that I have made regularly and in fact, when I stood up I had the inclination to say: "and as I was saying," because 3 years ago when I was the Assistant Administrator for General Aviation, I had a feeling I was saying essentially the same things, and very little has changed except the attitude of the FAA and that is the only bright spot.

So I would urge that we regularly remind them that we are their constituents: we are the ultimate arbiter of decisions, or should be, and we are the ultimate judges of how efficiently they do their job. If we can do that and maintain a working dialogue, then I think the prospects for the future are essentially unlimited. If we don't do that and have real lapses, we are signing our own doom in the general aviation community, simply because we'll be the first to go if the system doesn't improve and doesn't work.

Thank you very much.

GENERAL AVIATION USER VIEWS TO THE EVOLVING ATC SYSTEM

MR. DAVID SHEFTEL

I want to introduce the next speaker, John Winant, who is the president of the National Business Aircraft Association, is well known to many of us for quite a long time, and I think that typical of his stature in the aviation community is his role as chairman of NASA's Advisory Committee on the Aviation Safety Reporting, which is now a very active and useful experiment. I would like to introduce John Winant.

MR. JOHN H. WINANT

Thank you Dave, and thank you Sieg for inviting me to be with you here. I too am going to expedite what I had prepared in hopes that we can bring everything to a happy conclusion somewhere near on time, and I am sorry that some have had to leave us already. Now I particularly welcome the caveat which Sieg Poritzky used as the basis for his presentation on major development programs. He said that the underlying motive is "to help general aviation and not to stifle it in a super-complex, super-automated air traffic control system." Though I am a believer, and I doubt Sieg's sincerity not one jot nor one whittle, I must say to you that I do have, along with many others in the general aviation community, a rather deep, lurking sense of frustration as to just how many of these current developmental concepts will really come out at the end of the line. I predicate my sense of frustration of what FAA might do or might not do, and what we in industry might accomplish or fail to accomplish, and the fact that it does seem that, with respect to several of the major goals, what we have on our hands today is a situation which is growing more and more politicized, and that in the final analysis, the end of the line may be more directed by political considerations than by those factors which we, or you, in the FAA feel are more important to us. So let me explore with you a little bit, if I may, my frustrations, thinking that it is healthy to do so and that perhaps in the long run we'll all end up a little bit closer together by so doing.

In my view, three causal factors in the General Aviation fatal accident record, which was shown to you by Sieg, stand out as meriting concentrated and effective R&D effort and operational implementation. First is the fact that weather is the single most predominant causal factor. Fact two, in importance to me, is that pilot error plays an unfortunately inordinate, predominant role. And third, nearly 10 percent of all fatal accidents in general aviation involve in-flight collision. Sieg said it better in his talk than I am trying to say it to you now: "FAA aims for safety and efficiency at lowest cost and complexity to the user." Achieving that kind of

goal indeed does call for a very delicate kind of balancing. To me it says that what we need in the evolving ATC system is to further reduce the existing accident rate, and, additionally, to construct improved means which will prevent rise of a whole new set of leading accident causes. And finally, somehow, also to provide for the efficient handling of increasing numbers of general aviation aircraft. So I am going to state that goal number one, at least to me, in the evolving system, should be to promote safety and efficiency through an improved system of disseminating weather information. Now let me just leave that goal right there for a moment and then come back to it. Sieg pointed out that 9 percent---approaching 10 percent of general aviation fatal accidents involve in-flight collision. And he also pointed out very correctly, I believe, that the rate probably would increase as the aircraft fleet increases, particularly if no good steps are taken in the near future to erect system defenses against that kind of horrible accident. So I am going to choose as my goal number two, for the evolving system, the provision of means by which separation of aircraft can be assured at reasonable cost. And I will leave that goal right there for just a moment. Finally, even though the statistics shown do not focus on it, at least in numerical terms, it is a fact that an inordinate number of fatal accidents occur in the landing phase of flight. So the third goal I state is that provisions should be made for better landing aids at the maximum number of airports. To us, the MLS concept appears the best choice, and we support it.

So, three brief goals. One, improve the systems for disseminating weather information; two, provide for separation assurance; three, expedite the implementation of the Microwave Landing System. Each of these is a prominent FAA developmental goal, and I state that NBAA supports them fully and conceptually.

But let me take you back to the beginning and run by you the frustrations that I experienced with respect to each of these goals. We want modernization and automation in the Flight Service Station System, and in the system through which weather information is disseminated. The FAA wants modernization and automation, but it seems that frequently we aren't talking on the same wave length once we get past those two key identifier words. User organizations, as you have heard in particular today, believe that a keystone of the evolving ATC is an adequate means of gaining accurate, comprehensive information on which to make a very basic decision. And that decision is whether or not to enter the system. Vic Kayne has given you the details of general aviation's program, expressing our mutually determined aviation weather needs. In the briefest of terms then, we feel there is an urgent need for automation of the FSS network, and we recognize that the day of face-to-face, one-on-one, personalized briefings is behind us. There is simply not enough funding available to increase FAA manpower at FSS's to provide for that very nice oldtime arrangement. It seems to us, the longer it takes to give final shape to the improved weather services goal, the bigger becomes the spectre that someone else, the United States Congress, for example, is simply going to mandate a program for us. And frankly, given that kind of situation we have, of a long-term program which is yet to reach anything near fruition, a Congressional mandate might not result in the kind of program which we and the FAA feel might best answer our needs.

You all, I am sure, remember ELT legislation. As one example of what I'm talking about, Representative Hammerschmidt of Arkansas, who is a member of the powerful House Aviation subcommittee, has just introduced legislation which would establish 45 automated flight service stations, each with three identical automated data processors, and something like 96 remote data terminals. What we have seen of that proposal tells us that it will not meet the needs which we in general aviation have agreed upon and have supported for many months. And I would dare say that FAA has, or should have, misgivings also. So I suggest that what we need is a true intensification of FAA/industry efforts to bring the matter to an acceptable conclusion between us, so that we can put a neat checkmark, connoting completion, against the goal of providing improved weather information.

Goal number two: Provision of a separation assurance program. We endorse FAA efforts to develop equipment which will provide long-range answers to the in-flight collision hazard. We agree, as does most of the general aviation community, that the Beacon Collision Avoidance System, or BCAS, shows the best promise for providing protection to the largest number of aircraft at an acceptable cost, and we endorse fully a program of putting BCAS through an extended, thorough testing; and if the testing is successful, then to final review. We believe that with certain caveats that I will not go into now in the interest of time, that the system will provide for the maximum protection to the largest number of aircraft, and it should do so regardless of the speed and the operational characteristics of the aircraft. But with respect to BCAS, again, we are subject at all times to the pressures of the United States Congress. And I submit that if actions are not taken at the earliest possible date to conclude and reach a mutually acceptable system for providing aircraft separation, that the Congress of the United States, in utter frustration, is very likely to take the matter out of our hands and present us with a solution which we may not find totally acceptable. And finally, to wind up my remarks, a very brief note on the subject of Microwave Landing Systems: In very recent weeks, the MLS situation has been elevated, as we say in good Washingtonese, to an issue of monumental proportions. The FAA position is right now being subjected to very serious scrutiny by key members of the United States Congress. There are grave pressures being exerted on FAA by members of the Congress. There are very important and very serious international overtones, concerning the acceptance of the TRSB system or perhaps some of the competitor systems which are being promoted. And I close simply by emphasizing that once again, and with yet a third very major issue, the decision point may be taken away from that place where it can best be made, and that is the arena of discussion and review and study between FAA and industry, inclusive of those persons who will manufacture the equipment that we use.

And so in closing I would say that while I am frustrated, I am also optimistic; but I would appeal to FAA and those of us who are here representing the user community that what we need is a greatly increased, mutually cooperative effort between us, with the setting of reasonable time frames so that we do not have to wait into the 1990's to have major programs come to fruition. And I close simply by saying the date may be much earlier, but the system we envision may not be the system we want and need.

Thank you very much.

SESSION SUMMARY

MR. DAVID J. SHEFTEL

In this final session the uses of area navigation for General Aviation were outlined by both the R&D and Operational groups in the FAA. It is apparent that the concept of area navigation and the capability for its use by the general aviation community are now merging into reality. We expect to see area navigation bloom into a major aspect of general aviation flying.

In the discussions of microwave landing systems for General Aviation, we have outlined the R&D program to develop MLS and our concepts for MLS implementations. We are extremely pleased with the technical progress that has been made in developing low-cost MLS systems and in the increasing acceptance of the U.S. MLS concept for the aviation community. I hope that all of you have taken the opportunity to examine the MLS equipment here at NAFEC and to discuss the program with our staff.

The Air Traffic Control improvements envisioned by the FAA as discussed at this meeting, will greatly increase the capacity of the Air Traffic System while assuring safety and minimum cost for all concerned. Programs such as DABS, Automatic Traffic Advisory, and Collision Avoidance Systems certainly were expected to get the enthusiastic attention of Mr. Baker and Mr. Winant in their presentations.

CONFERENCE SUMMARY

MR. ROBERT L. FAITH

Thank you David. Ladies and gentlemen: I do honestly and sincerely hope that you have enjoyed these 2 days, and it is my distinct pleasure to introduce to you the Deputy Administrator of the FAA, Mr. Quentin Taylor, who will make the closing remarks.

MR. QUENTIN TAYLOR

Good afternoon. John Baker was wondering whether or not those of us who are in place presently have enough concern for the future to want to be around whenever, whatever happens would happen. I want to go on record today committing myself to that proposition of being around when it happens, and also to demonstrate to you, via those particular words, my confidence and faith that our efforts today, will be our efforts in the future. Being around tomorrow in aviation is going to, in fact, be worthwhile. Now that I am no longer an engineer, I suppose I am a policy guy, but I believe that you will find myself, and also Langhorne Bond characterized as planners. Personally, I am prevention oriented, and prevention oriented in these particular ways. I am accident prevention oriented, I am high-cost prevention oriented, I am airborne-confusion prevention oriented, I am aviation-capacity constraint prevention oriented, and I intend to stay that way. In my leadership within FAA, I would hope that prevention orientation is the thing which would allow us to develop, on a continuum, a healthy aviation environment; that is, solve the problem, prevent the problem before the costs are so high and the means are so complex that we are unable to solve the problem. It has been a busy couple of days for you, and I am sure up until yesterday rather warm, but I would like to thank each of you on behalf of the agency for your interest and participation in what it is we are doing in the field of General Aviation. Also, a special thanks to our industry friends, Jack Eggspuehler, Jim Pyle, Austin Brough, Stan Green, Vic Kayne, John Baker, Bill Horn, and John Winant, for their invaluable efforts in making this conference the success that we feel it has been. I hope that you found the conference rewarding, informative, and interesting. We certainly found it that way, and I believe today, certainly yesterday, and in the future, we will begin to use this bridge of communication, explanation, and dialogue, as a way to build a healthier aviation future, particularly in terms of General Aviation. In his opening remarks, Mr. Bond expressed our commitment to enhancing General Aviation's role in this country's still burgeoning air transportation system. Speaking for myself, during my years in the Washington FAA Headquarters, Alaska, and the New England Region, I hope I have developed in many, many ways, a keen sense of the importance of the many facets of General Aviation to the American scheme of things. The point is, both Mr. Bond and I have a real awareness of the General Aviation economic and social benefit role in this country's future. We solicited your support for our R&D programs. We have been highly pleased at your responsiveness and your suggestions. Assuredly, we can, we shall crystalize the direction and emphasis of applicable R&D programs. This is as it should be. We need your support to help us get the rationale of your, and and let me underscore your, programs approved and funded by Congress. I would only ask that

you restrain yourselves, constrain yourselves in perhaps premature criticisms of investigatory work that is yet to be completed. I ask this in the sense that, very often in engineering and development, research and development, and systems analysis, it may seem that the benefit of a particular work or the benefit of the evolutionary system will not suit your own needs, and indeed, in many instances that is fact. It may not happen, in some cases, it does not happen. So, I ask that you not cease to criticize in a constructive sense, certainly inform us, certainly counsel us, but I would ask that you restrain yourselves in perhaps premature criticism such that the industry itself does not realize the benefits or spin-off benefits of that investigatory work that might have been done. On the subject of general aviation airmen's programs, we all know that weather-related factors account for a very large percentage of general aviation accidents, so I am very much in accord with the suggestion made yesterday that would place much more emphasis on instrument training. In that connection, there is a corollary requirement, I believe, that we are going to have to insist on a general upgrading of flight instructional programs, as well as the quality of flight training provided. This, in turn, will mean that we must upgrade flight instructor requirements and the quality, as well as the breadth of training provided. In the area of medical research, I was somewhat fascinated with the suggestion that we consider a program aimed at defining the physical age rather than the chronological, or calendar age of a pilot. I wondered, in hearing of that particular commentary, whether or not I was listening to another group of people. It is somewhat strange that it would come from the general aviation community. I have heard that from ranks of air carrier pilots, first officers, and so on, but not from General Aviation. It is amazing to me, as I have grown older, how young older people are becoming. I can tell you that Dr. Rieghard, our air surgeon, and Stan Mohler and company, are investigating this particular facet of airmen aging, such as to make a more rational determination as to the capacity and capability of a given pilot. I do not know what our findings will be on that given subject, but nevertheless, it is an interest item to us and our work is somewhat pointed on the subject.

In response to our Airports R&D Programs, I am pleased that there was general agreement on the work that we are doing on low-cost marking and lighting for small airports, frangible light structures, and low-cost fire-crash-rescue equipment. The big problem, as you all certainly recognize perhaps more pointedly than I, is how we can support the airport owner, particularly that owner of a private airport which is available for public use; perhaps using ADAP funds, but necessarily making that airport operator the beneficiary of FAA's Research and Development Program. Well, we have to consider the financial condition of the smaller airports, along with other issues associated with ADAP funding, taxation, financial support, and then finally, the legislative intent which supports ADAP. It is an issue of great concern and it does need to be addressed by the Federal Aviation Administration. I do believe that it can be solved. If I might, for just a second here, return to the subject of airmen and aircraft. We have, and will continue to, place heavy reliance on the use of NAFEC's facilities and personnel to improve our policy and regulatory actions, thereby hopefully, improving the professionalism of pilots and the quality of aircraft. I believe we are going to have to go all out on such projects as the development and the use of flight training devices and simulators.

It is part of our future. We have to do far more with respect to stall awareness training and we have to overcome the problem of degradation in pilot performance under instrument flight rules, to name just a few of the pressing issues. But in doing so, our answers must be tempered by the economic issues that go hand in hand with our quest for flight safety. On the subject of air traffic control, area navigation in particular, it is apparent that the concept of area navigation and the capability for its use by the general aviation community are drawing close to operational reality. We expect to see area navigation bloom into a welcome, and major, aspect of general aviation flying at the right cost and fully integrated with other advances. With respect to the microwave landing system, I can complete my discourse on that subject, very, very quickly, by saying that I absolutely agree wholeheartedly with John Winants' statement earlier on the subject: simply said, we need to get our act together on that particular subject among others, and if we do not, the future of General Aviation, if not all of aviation will be severely weakened. In an allied area, there seems to be general agreement that the wind shear and wake vortex efforts are important safety-related tasks which must be continued at a rather rapid pace. As was pointed out, the work detailed thus far, really represents only the tip of the iceberg.

As far as our weather programs are concerned, and this is an area of personal and professional concern to myself, the consensus appears to be that the R&D program to provide more timely, accurate, automated, and expanded weather information should be continued and, in fact, needs more emphasis. A number of policy questions were raised by the AOPA representative, Mr. Vic Kayne, regarding the use of ADAP funds for the acquisition of such weather systems. We shall take a very close look at that particular subject, and I think that we can provide AOPA and the others who are interested in this particular subject, with some answers to their questions rather quickly. I believe, and this is a personal belief rather than a well-substantiated one, after investigation in terms of law and so forth, that it can be done. After all, accurate weather information, timely weather information is just as much of a safety requirement as several more thousand feet of concrete or a TCA. It is needed, and it is particularly needed in the area of General Aviation. We shall see what we can do there. The subject of the flight service station modernization did raise great interest. It continues to be a subject which weighs upon my mind. User representatives indicate they do not agree with several aspects of our flight service station modernization program; they feel it is dragging. They are absolutely right. They feel that it could, and should be, substantially accelerated. It shall be. There also seems to be some feeling that the subject is not so much an R&D problem as it is an implementation problem. That is true. I have examined that particular issue. One thing that I do promise; we will get user groups and our own people together. We already have taken steps in that direction. We shall anticipate, and completely obviate, the need for congressional reaction on this particular subject. Within the space of several weeks, we should be at a point whereby the Secretary of Transportation and those persons interested in the subject at the Office of Management Budget would have been fully advised and appraised of our plans. At that particular time, we would listen to your particular views on the subject with the idea of moving forth in a concerted way for the first time, really, in about 5 or 6 years.

To conclude, this is the first, but I am confident really not the last, meeting of this particular type. It is particularly important to us, for we are trying, indeed we intend to establish a close rapport with all segments of the general aviation community. We can do it best, I think, by demonstrating our plans, our policies, our programs, such as we have done here at NAFEC. It is really one facet of FAA's "we'll tell you what we are doing" program. I think it is effective, I trust and hope that you have found it effective. Our purpose is really straight forward. As the needs for air transportation increase, we know that the general-aviation fleet, airmen, airports, and operations are going to increase significantly. These increases will require a commensurate emphasis by us--and by you--to improve safety, to provide that capacity that will be needed. This will, of course, require more, and better, communications and understanding between us if we are to assure flight safety, a more efficient national airspace system, and a system which in effect has more capacity than we are able to realize today.

On behalf of the Administrator, myself, and for NAFEC, indeed all of FAA, I would like to thank you all for being here, for joining us and we hope that this is the beginning of a more beneficial process in our communications. We look forward to this kind of a thing happening in many, many more forums, many, many more streets of our aviation endeavors. I would simply like to say in closing that I am relatively new at my particular desk. I would hope to continue to demonstrate or show you that our knowledge in respect to the needs of General Aviation is on the upsurge, it will continue to grow. I certainly have your interest at heart and I recognize that some 174,000 aircraft out there mean something. Some 600,000 pilots certainly mean something. When I take a look at the projections and recognize that very shortly the general aviation fleet is going to exceed 250,000 aircraft, and our airmen totals will increase in a commensurate sort of way, that is the growth problem, that is the safety problem, that we simply cannot ignore. Our technology must treat it, our economics must treat it, and I have committed myself to doing exactly that.

Thank you.

GLOSSARY

AAAE - American Association of Airport Executives

AAM - Office of Aviation Medicine

AAP - Office of Airports Programs

AAT - Air Traffic Service

AC - Advisory Circular

ACE - Federal Aviation Administration Central Region

ADA - Office of the Deputy Administrator

ADAP - Airport Development Aid Program

ADF - Automatic Direction Finder

AEA - Federal Aviation Administration Eastern Region

AED - Associate Administrator for Engineering and Development

AEM - Office of Systems Engineering Management

AEQ - Office of Environmental Quality

AEU - Federal Aviation Administration Europe, Africa, Middle East Region

AFS - Flight Standards Service

AGA - Office of General Aviation

ALDI - Automatic Landing Direction Indicator

ALPA - Air Line Pilots Association

ALS - Approach Light System

ALSF - Approach Light System-Frangible

ANA - Routing Symbol for NAFEC

AOA - Office of the Administrator

AOPA - Aircraft Owners & Pilots Association

APA - Office of Public Affairs

APD - Associate Administrator for Policy Development and Review

APEER - Aircrew Performance Enhancement and Error Reduction

ARC - Aircraft Radio and Control Division (CESSNA)

ARD - Systems Research and Development Office

ARM - Federal Aviation Administration Rocky Mountain Region

ARP - Aerospace Recommended Practice

ARTCC - Air Route Traffic Control Center

AS/ATC - Air Space/Air Traffic Control

ASP - Office of Aviation System Plans

AT - Air Traffic

ATC - Air Traffic Control

ATCPA - Air Taxi and Commuter Pilots Association

ATCRBS - Air Traffic Control Radar Beacon System

ATIS - Automatic Terminal Information Service

ATP - Airline Transport Pilot

ATR - Airline Transport Rating

ATS - Automated Terminal Service

AV-AWOS - Aviation Automated Weather Observation Stations

AVP - Office of Aviation Policy

AWANS - Aviation Weather and NOTAM System

AWOP - All Weather Operations Panel (ICAO)

BCAS - Beacon Collision Avoidance System

CAA - Civil Aeronautics Administration

CAMI - Civil Aeromedical Institute

CAT - Category

CDI - Course Deviation Indicator

CHT - Cylinder Head Temperature

CO - Carbon Monoxide

CRT - Cathode Ray Tube

CSC - Computer Sciences Corporation

CTI - Champlain Technology, Incorporated

DABS - Discrete Address Beacon System

DME - Distance Measuring Equipment

DOD - Department of Defense

DOT - Department of Transportation

EFAS - Enroute Flight Advisory Service

ELT - Emergency Locator Transmitter

EPA - Environmental Protection Agency

FAA - Federal Aviation Administration

FAR - Federal Aviation Regulation

FBO - Fixed Base Operator

F&E - Facilities and Equipment

FL 180 - Flight Level 18,000 feet

FSS - Flight Service Station

FT - Terminal Forecast

GA - General Aviation

GAMA - General Aviation Manufacturer's Association

GAW - General Aviation Whitcomb (Airfoil)

G.E. - General Electric

HAA - Helicopter Association of America

IBM - International Business Machines

ICAO - International Civil Aviation Organization

IFR - Instrument Flight Rules

ILS - Instrument Landing System

LTO - Landing, Take Off

MALS - Medium Intensity Approach Light System

MDA - Minimum Descent Altitude

MLS - Microwave Landing System

NAFEC - National Aviation Facilities Experimental Center

NAFI - National Association of Flight Instructors

NAS - National Airspace System

NASA - National Aeronautics and Space Administration

NATA - National Air Transportation Associations, Incorporated

NAVAID - Navigation Aid

NBAA - National Business Aircraft Association

NDB - Nondirectional Beacon

NJDOT - New Jersey Department of Transportation

NOS - National Ocean Survey

NOTAM - Notices to Airmen

NO_x - Oxides of Nitrogen

NPA - National Pilots Association

NPRM - Notice of Proposed Rule Making

NTSB - National Transportation Safety Board

NWS - National Weather Service

OMB - Office of Management Budget

PATCO - Professional Air Traffic Controllers Organization

PATWAS - Pilot Automatic Telephone Weather Answering Service

PIREP - Pilot Report

POMOLA - Poor Man's Optical Landing Aid

RAIL - Runway Alignment Indicator Lights

R&D - Research and Development

RFP - Request for Proposal

RNAV - Area Navigation

RTCA - Radio Technical Commission for Aeronautics

SA - Hourly Observation (Weather)

SAE - Society of Automotive Engineers

SAVASI - Short Approach Visual Approach Slope Indicator

SCMLS - Small Community Microwave Landing System

SIAS - Safety Information and Analysis System

SIDS - Standard Instrument Departures

SRDS - Systems Research and Development Service

SSALSR - Simplified Short Approach Light System with RAIL

SST - Supersonic Transport

STARS - Standard Terminal Arrival Routes

SWIMS - Surface Wind Monitoring System

TACAN - Tactical Air Navigation

TCA - Terminal Control Area

TCM - Teledyne Continental Motors

TERPS - Terminal Instrument Procedures

TRSB - Time Reference Scanning Beam

TSC - Transportation Systems Center

TSO - Technical Standard Order

TST - Office of the Secretary of Transportation

TWEB - Transcribed Weather Broadcast

UPI - United Press International

USDA - United States Department of Agriculture

VAS - Vortex Advisory System

VASI - Visual Approach Slope Indicator

VFR - Visual Flight Rules

VHF - Very High Frequency

VOR - Very High Frequency Omnidirectional Radio Range

VORTAC - Very High Frequency Omnidirectional Radio Range and Tacan

VRS - Voice Response System

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Egg Harbor News

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Flying Magazine

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FAA/ARD-50

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